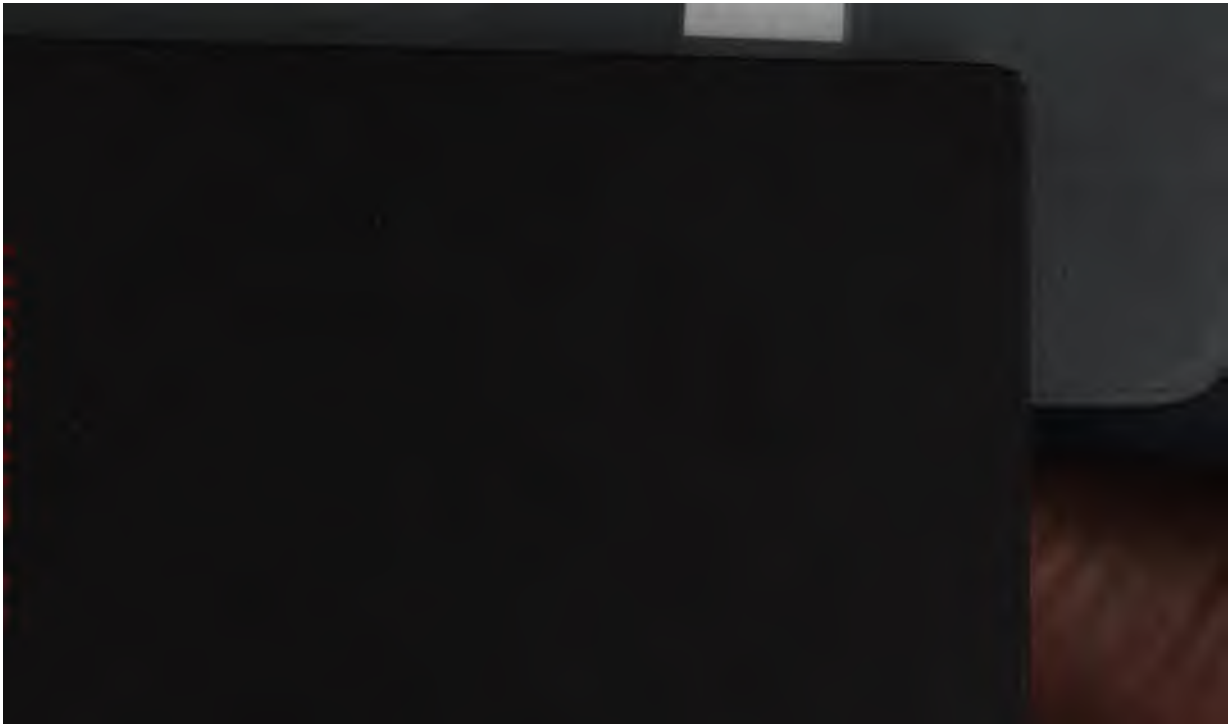

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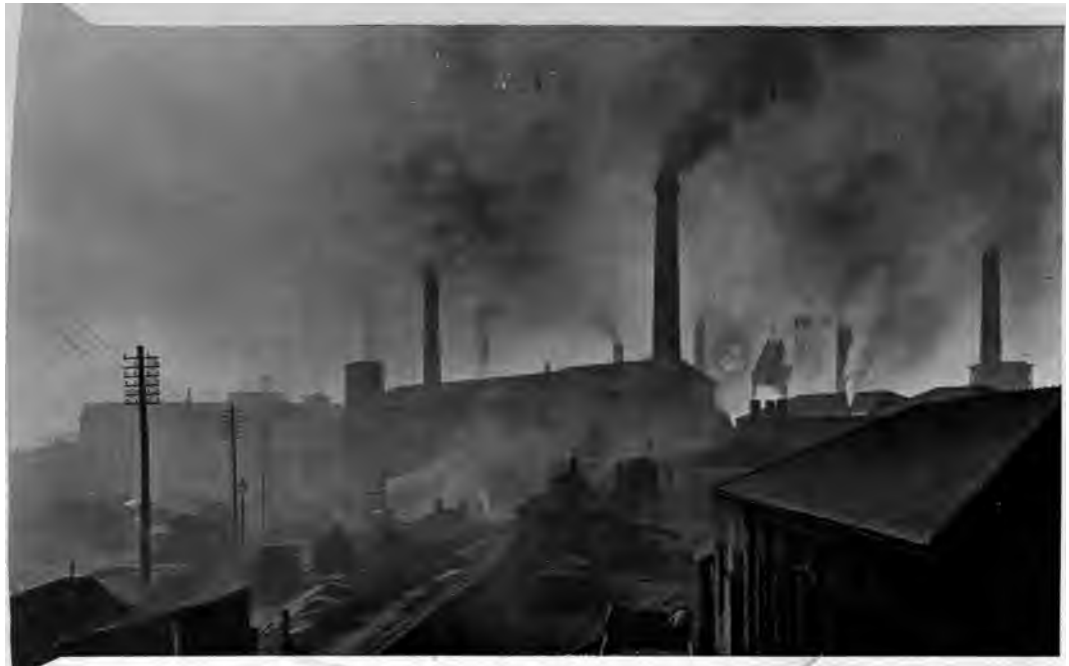
THE DESTRUCTION OF DAYLIGHT



WARRINGTON: CROSFIELDS' CLEAN CHIMNEYS IN THE DISTANCE TO THE EXTREME LEFT

THE DESTRUCTION OF DAYLIGHT

A STUDY IN THE SMOKE PROBLEM

BY

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PREFACE

THESE pages do not aspire to teach anything to the smoke expert. They are not an original research in chemistry or in engineering. It will be sufficient if they are found to be correct, so far as they go, in their chemical and engineering facts. They are rather addressed to the ordinary manufacturer and to the citizen, for it is in their hands that the cure now lies. The engineers have provided for every case smokeless, or nearly smokeless, devices of which these pages contain information.

It is now for the public to amend and, above all, to enforce the law.

This is an appropriate time for an attack upon smoke. Many minds are turning gravely to face the waste of our national capital in coal, and anything which promises economy of power is eagerly sought. It is well that cleanliness, health, economy, and

efficiency all pull the same way. The Report of the Royal Commission on Coal Supplies, issued in 1905, will, I hope, mark a new point of departure.

The book was ready for the printer before the claims of Coalite were brought before the public. It receives such mention as is at present safe, and we can only earnestly hope that it may work the revolution anticipated.

These pages will be found to contain frequent references to Ruskin's works. But this is appropriate, seeing that they have been written at the request, and under the auspices, of the Guild of S. George, founded by Ruskin, as readers of *Fors* know, in 1871.

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Oh, to be in England
Now that April's there,
And whoever wakes in England
Sees, some morning, unaware,
That the lowest boughs and the brushwood sheaf
Round the elm-tree bole are in tiny leaf,
While the chaffinch sings on the orchard bough
In England—now!

ROBERT BROWNING, 1842.

We have, in the towns, little spring-time and no autumn, and nothing that can be called weather in the old-fashioned sense, in England —now!

THE MAN IN THE STREET, 1907.

THE
DESTRUCTION OF DAYLIGHT

CHAPTER I

SMOKE

BEFORE the days of modern cities smoke could be sent up into the clean air without harm. The sky was relatively so vast that the atmosphere was not seriously dirtied before the carbon and the sulphur acids descended along with the rain harmlessly again to the earth. But the air can no longer be kept clean without regulation. There have been added to the domestic fires of our crowded towns pillars of black cloud which the manufacturers pour into the air as if the air were their own. Similarly there were ages when men were few, and the happy hunting grounds of earth and water were free to all: these have long passed into the stage of private property or special right in

a way in which the indivisible and unfenceable air can never pass.

But land and water have reached a third stage, in which the community, by legislation, by taxation and by manifold bye-laws of local bodies, has in the public interest asserted its paramount and original rights. Everything points to a tendency to strengthen the hold of the State upon the land. This third stage has to be reached for the atmosphere without passing through the second; the time has long ago come when the community can no further neglect to guard or to resume its indefeasible inheritance of pure air, as a necessity not perhaps of mere life, but of health and ordinary happiness. We live more close to the air than we do to the land or the water; we bathe in it all the time; it not only affects our clothes and our skins, but we breathe it with all its impurities into those delicate passages of the lungs which were made for the abode of its pureness only. To foul the air is to condemn us all in the most intimate fashion to dirt and darkness, and to a sad universal ugliness.

Sunlight among the foliage of green trees or dappling the pure stream—sunshine on grass or on distant hills—clear gleams after rain—golden settings and risings—these are

the lovely things of the earth. On sunshine depends the beauty of all glorious animals and plants, of the peacock butterfly and the daisy of the field. We too are creatures of sunshine by nature and inheritance; to be deprived of light is to us a species of starvation and imprisonment. The town dweller of to-day has in fact ceased to expect to live in sunshine; but he is descended from ploughmen and milkmaids, who for countless generations before the factory system arose, lived open to the sun. Our organisms, which have been developed through these generations to meet this environment, still need it, and must plainly suffer for want of sunshine. We know too well the pale children of our streets, the weakly delicate young women of our towns. Why do they differ from country children with their robust limbs and tanned faces? Why are they denied the happy health of the company one meets at a village flower show? Food and wages and sanitation are probably better in the towns. The atmosphere is largely responsible for the difference, aggravating all overcrowding; and the atmosphere is made what it is by smoke.

On a single page of the *Manchester Guardian* this morning a particularly careful observer states that really clear summer

days in Cheshire are fewer of recent years, due to the extension of manufactories and an increased output of smoke; and a Philistine correspondent objects to the building of a new Art Gallery because you cannot observe objects of art on more than 15 per cent. of the days in a year. (This conclusion is, of course, nonsense, for is there not electric light?)

We are told by Charles Booth that Londoners do not survive as Londoners beyond the third generation, but some of our great cities are smokier and less healthy than London through burning a smokier coal. The race is being made weak, bloodless, and depressed; for about four-fifths of our people live in towns under a smoke cloud. Sir Thomas Barlow says concerning health: "Recent investigations have shown that the value of direct sunlight is absolutely untold."

Dr. Tatham, the Medical Officer of Health for Manchester, stated in his report in 1890 that the working life of people in Manchester township, which is the central part of the city, and not worse than many other towns, was curtailed by ten years. They are worn out ten years before their time. The average expectation of life among men

from 1881–90 was stated by him to be for England and Wales 43.66 years; for the country districts 51.48 years; for Manchester 28.78 years. Our people lose 30 per cent. of their lives, says Dr. Tatham. What days of weariness and pain, what encroachment of weakness and ill-health in the prime of life, all this means. The acids of smoke and its carbon particles operate upon the lungs for years before they finally destroy them.

Sunlight is also a valuable disinfectant: light kills certain bacteria. The typhoid germ, for instance, dies under intense light.

Plants are darkened as well as choked by soot and the sticky tarry products which are found in smoke. It is only under sunlight that they give off the oxygen we need from them, and take up the carbonic acid from the air: this is their breathing, and it is as necessary to them as ours is to us. Smoke also kills plants by lessening the fertility of the soil, through settling upon it and making it impervious to the air, so that it becomes sour. In the garden at the Bank of England the leaves have to be washed with soap and water every week. In the public garden attached to the University Settlement, Ancoats, Manchester, the plants nearly all die and have to be renewed each spring; one

cannot lean against a tree there, or sit on a garden seat, without spoiling one's clothes.

From observations made during the five winter months of 1898–99 we learn that in London there is in winter half as much sunlight as in the South of England generally, a little more than one-third of what is recorded on the south coast stations, and only 12 per cent. of what is astronomically possible.[1] In other words, an eight hours day gives the Londoner one hour of pale sunshine only.

The sun in a great English town may be seen on an average winter day only before breakfast, and for a conquering hour or two after midday. This last peculiarly sunny summer of 1906 gave the inhabitants of Manchester five and a half hours sunshine per day during the four summer months; and most of this must have been before they rose in the morning. In October they had less than two hours per day.

When Alkestis was making lamentation for her approaching death, her cry was that she would never more see the sunrise or the sunset—

> "Willing to die instead of him, and watch
> Never a sunrise or a sunset more."

---

[1] Dr. W. N. Shaw, San. Inst. Congress, Manchester, 1902.

In Homer the wail for loss of life centres in a last farewell to the light of the sun. But most of our population have ceased, in an ordinary way, to see sunrises and sunsets; they, if they think of death, miss seeing the cheerful street lamps and the exhilarating glories of the well-dressed shop fronts. The British Empire, it has been said, is one on which the sun never rises.

In cities like this all heart is taken out of the effort to design or to pay for or to enjoy beautiful buildings. Forty years ago, Ruskin, speaking to the Society of British Architects, said:—

"All lovely architecture was designed for cities in cloudless air; for cities in which piazzas and gardens opened in bright populousness and peace; cities built that men might live happily in them, and take delight daily in each others' presence and powers. But our cities, built in black air, which, by its accumulated foulness, first renders all ornament invisible in distance, and then chokes its interstices with soot; cities which are mere crowded masses of store, and warehouse, and counter; and are therefore to the rest of the world what the larder and cellar are to a private house; cities in which the object of men is not life, but labour; and in

which all chief magnitude of edifice is to enclose machinery; cities in which the streets are not the avenues for the passing and procession of a happy people, but drains for the discharge of a tormented mob, in which the only object in reaching any spot is to be transferred to another, in which existence becomes mere transition, and every creature is only one atom in a drift of human dust and current of interchanging particles, circulating here by tunnels underground, and there by tubes in the air; for a city, or cities, such as this no architecture is possible—nay, no desire of it is possible to their inhabitants."

And so the rich, and the well-to-do, and the modestly comfortable people, go away. Classes are separated in England chiefly by the accidental conditions of our fuel combustion. Had we been fortunate enough to burn anthracite or wood or natural gas, we might have realised better our common citizenship.

All those who can afford it find that they flag unless they leave town for a summer holiday in the country and for short holidays at other times. Into this necessity other elements besides the state of the atmosphere enter, but the longing for more fresh air than we have is strong and universal; and however

anomalous it is that we cannot find fresh air at our ordinary homes, we have become so used to it that it does not strike us as curious. But think of the condition of those poor—that is of the nation at large—who cannot take their month in the country, but must be content with a few crowded days, or a week of frantic fun, which is not rest, on the roaring promenade by the sea. The poor must, broadly speaking, find air and brightness at home, or nowhere.

The effect of our atmosphere on temper—and thereby ultimately on temperament—is disastrous. What of the weary shop-girl trying under the electric lamps to suit her customers, who are themselves tired and choked by fog? Think of the case of the teacher in the crowded elementary school in the murky afternoon, fighting the gloomy elements, and it is to be feared the children too, at the hour when the sunset light and the fresh air are coming in at the open window of the country schoolhouse. We are becoming nervous and irritable, wanting in the quiet calm of country contentment, and smoke is among our irritants. We know how different the powers of all of us would be if we breathed pure air, and on most days saw the sun.

The fact is that we run up against the smoke nuisance in every effort to bring brightness, cleanliness, health, and even peace of mind to our working-class households; for when the fog is in the throat, and its smart in the eyes, and its dirt on our hands and on everything we touch, cheerfulness and politeness and most of the graces and benignities of intercourse are more difficult. If the working-class woman had the sun streaming in at her window, and her children were playing on the grass outside instead of in the black streets, her temper would be less sharp, her husband's evening life would be a quieter one, he would be more inclined to stay at home and so would drink less. It is hard indeed to make a little home in a grimy street as bright and as refreshing as a public drinking place. I once heard a woman in Oldham explain to a sympathetic audience that she had had a large family to "contend wi'," and the force of that touching and expressive verb was, I am sure, heightened by the fact that the children with whom she had to "contend" had a remarkable aptitude for dirty faces and impossible hands. The upper class men or women who try to be clean justly complain of their laundry bills, but what of the industrious working woman with

her clean doorstep and window ledge, her transparent panes of glass and her shining hearth? These represent a large part of her working life, an immense tax of toil. She is brave indeed if she manages to have her children clean once a day; their clothes cannot be clean—they never are; and they do not smell clean if you encounter them in a mass. Every week some six hundred children crowd into the large room of the University Settlement in Manchester, and six hundred throats roar with joy whilst they are entertained for an hour and a half; but the room is not fit to breathe in—it is permeated by the peculiar smell of six hundred dirty suits of clothes. The children, besides being dirty, are thin, undersized, and spotty. Two rows of cripples are at the front in reserved seats. These are the English folk. When we talk of Englishmen we need not consider such people as Oliver Cromwell, or the Duke of Wellington; these children are the English people, and, moreover, they are the English of the next generation, upon whom the national future depends.

It may be worth while to inquire whether a purer air would have much effect on trade and wages. It would make town life pleasanter, and so tend, other things being equal,

to lower the "nominal" wages paid by the employer, whilst not diminishing the "real" remuneration received by the workman, or it might tend, and more probably would, to give him more "real" wage, whilst leaving his "nominal" wage unchanged. In fact, clean air would—slightly—stand for so much wage. The higher ranks of workers too would not have to live so far from town, and therefore a man would not have to deduct five or ten pounds a year from his salary for a contract ticket before he estimated his nett receipts. He can therefore take a lower salary without loss to himself; or he might keep his present salary and gain the difference: which causes a gain either to economical production or to human life. The largest economic result remains, in the greater vitality, the stronger nerves, and the longer working lives of our industrial population, if they lived in clean air. This would mean a gain in their power of production, and an increase in the reward of labour without increasing the real cost of production of commodities.

The fact is that the smoke evil is a real and pressing one over the larger part of modern England—not only over the great areas which are the centres of population and

manufacture. Smoke particles travel far, for however good the wind may be, all the solids which go up have to come down again somewhere. The area of smuts extends for forty miles round London. The Hon. Rollo Russell, observing the atmosphere for many years at a distance of forty miles south-west of London, has been able, after many records, to prophesy, by noting the velocity of the wind from the north-east, at what hour the London morning smoke will arrive, and his views be obscured in a brown haze. After a smoke fog at Richmond he finds "a thick black deposit on the leaves of trees, and when the ponds are frozen the ice is soon covered with dirt from the foul and gloomy air." The moors in Derbyshire are dirty to sit down upon, and the sheep upon them are dirty in colour. Even the Lake District is not entirely free. From the top of Bow Fell the other day, when the sky was clear and the sun was hot, I could see the reason why the lower valleys were kept in a slight haze, for the upper part of that haze was of the well-known dirty brown colour, and hindered the evaporating effect of the sun: it was made of smoke, and had come, with several days' south wind, from iron-works and foundries far away. Mr. W. G. Collingwood tells me that he has

noticed from the top of Coniston Old Man this dark cloud arise from the chimneys of the iron-works round the Furness coast, and then slowly move north and cast its gloom over the evening at Coniston and Windermere, where at least one hoped that natural beauty was safe.

I write this on a sunny hillside in the open air in the Lake District. Over the valley is to be seen the little knoll where Wordsworth consecrated himself under the early morning sun to a lifelong communion with nature, and to ponder on and tell of the relation of the human soul to the Soul of the World. The whole valley is Wordsworth's land, where he spent nine years of boyhood. Over the hill nestles Brantwood in its copses of oak, the home of Ruskin—in his thoughts, in his words, in his life, the prophet of the Divine beauty. Neither of these great voices would have been raised at all had Ruskin and Wordsworth had to live in South Lancashire instead of in the Lake District or other sunny places all their lives: if their perceptions had been blurred by always looking at our great grey monochrome of grime. Ruskin says: "Of myself, however, if you care to hear it, I will tell you this much: that had the weather when I was

young been such as it is now, no book such as 'Modern Painters' ever would or *could* have been written; for every argument, and every sentiment in that book, was founded on personal experience of the beauty and blessing of nature, all spring and summer long; and on the then demonstrable fact that over a great portion of the world's surface the air and the earth were fitted to the education of the spirit of man, as closely as a schoolboy's primer is to his labour, and as gloriously as a lover's mistress is to his eyes." What would thus have been lost by these our best, is in less degree lost by ordinary men in the modern town or colliery district.

If Plato is right in the *Phædrus* that lovely things exhale a lovely influence on the human spirit, and conform those who see them to their own beautiful nature, and if Wordsworth—that true Platonist—is right, that

> "Beauty born of murmuring sound shall pass into her face,"

then, indeed, we are exiling our masses from much that in the inward as well as the outward makes life an experience worth having. "You cannot have a landscape by Turner," says Ruskin again, "without a

country for him to paint; you cannot have a portrait by Titian, without a man to be portrayed. The beginning of art is in getting our country clean, and our people beautiful. There has been art where the people were not all lovely, where even their lips were thick, and their skins black, because the sun had looked upon them; but never in a country where the people were pale with miserable toil and deadly shade, and where the lips of youth, instead of being full with blood, were pinched by famine, or warped with poison." Smoke scatters sadness with its dirt, gloom of mind with gloom of eye.

To speak of the religion of beauty and its desecration is to raise deep issues. To myself it hardly appears as though the love of beauty can be the central experience of a religion. Religion is the recognition of—and love of—a divineness in human affairs and ordinary life; it is devotion to God—a finite life lived in the consciousness of the Infinite. It is true that we do recognise the beauty of the world as a part of Divine energy, as the garment of God, and so draw the love of nature up into divinity, but I do not believe that we grasp God by grasping His garment only. The pure and undivided

heart, the consecrated will, the life of obedience and hope, are the root of the matter, and I think are conditions for the religion of beauty which along with them comes in all its charm. A man who ignores the ethical commands of his religion may use and enjoy beauty indeed, but it will be an indulgence, a delight, not a religion. There is more religion after all in a slum chapel than in the shaded groves and sunlit sea at Monte Carlo. It is to a freshly purified spirit that the beauty of the earth makes a sudden appeal. It was immediately on his spiritual liberation and fresh consciousness of God that George Fox says, that "the whole creation gave a new smell unto me beyond what words could utter." Cowper in contemplating the work of nature enters into a religious communion with it, in the thought that "my Father made them all." Ruskin never climbed a mountain alone before he was forty without dropping on his knees at the summit to give thanks for what he saw. Browning seems at first sight to put the sequence otherwise—

> "O world, as God has made it, all is beauty,
> And knowing this is love, and love is duty."

But for the context this would seem to run

counter to the idea that only those in whom a measure of duty and love are already active will find them stimulated by beauty. But the context explains it. It is only after having his brow bared after the healing ministration of the Guardian Angel, and when "all lay quiet, happy, and suppressed," that the man is able to realise the sequence of beauty—love—duty.

Nevertheless, when the central motive is thus right, how religious, how divine, becomes every lovely thing. "What need of temple," indeed, as Browning says in "Easter Day," "when the walls of the world are that?" We rejoice in sight and touch of the garment of God, and feel that its defilement by dirt and poison is a pollution of sacred things.

Our joy in this beauty is our first, and it remains our most pure and mighty recreation; deprived of it the wandering quest of men leads them to find their pleasure elsewhere—in alcohol—in gambling—in melodrama. Lurid are the artificial substitutes for blue sky and the glory of green leaves: tinsel ornaments, trumped-up emotions, vicarious excitement, are called in; and the variety theatre and the music hall attempt the work of mental refreshment which might have come from woods and

fields in shade and shine. The beauty of bright sunbeam and glowing colour is one of which one does not tire and one cannot have too much. For our ecstasy, our passions, other gateways are provided, with their checks and their supreme need for moderation; but for this pleasure no check is needed, for no surfeit is possible: it is a joy without reaction, refreshing, restful, and calm. The fiercer pleasures of appetite, the passions of the flesh, exist not for themselves, or only incidentally for themselves, but are the necessary spur and incitement to the maintenance of the race; they may run to ruinous excess and become demonic; they can so invert the right order of things that men may live to eat rather than eat to live; but this delight in the beauty of the earth is not bound up with maintenance; it is an end in itself; and becomes more pure and beautiful the more it is cultivated. Are we not here touching an ultimate good? Is not this among the things for which we exist, we and our passions and all our toils? This is among the ultimate things for which we maintain the race.

It is noticeable and discouraging that natural beauty does not apparently appeal much to most of the toiling poor. The

farmhouse in the mountains usually faces away from the view up the hillside, and the windows look out upon the farmyard and the barn. All this means warmth in winter, security in the old Border forays, and convenience in daily work; but for many generations both the æsthetic and the convenient might have been achieved. It would seem as though with the majority of mankind the elementary needs of livelihood have to be satisfied before the mind becomes at sufficient leisure to enter into its inheritance. But so much of its inheritance as can be satisfied by sunshine, cleanliness, and fresh air is eagerly grasped by poor and rich alike.

If we leave a workman food and drink, and a home with wife and children in it, and the newspaper to be read in the gaslight, but deprive him in his grimy street of the beauty of the world, have we deprived him of what is necessary to the soul? I believe that he retains the necessaries of the moral life, he is not prevented from being a good man; nor are the flowers of culture pulled up by the roots, but they are nipped off at the top; we are starving his faculty and hindering development; he has lost interest in spring showers and in lengthening days; he knows nothing about the wheat and the

weather; he relieves the unnatural tedium in undesirable ways. One cannot say that the love of beauty is the foundation of conduct and character, but we believe that it is one of the final rewards of a rightly ordered life. Ruskin said once *more suo* that the main purpose of education was "to see the sky." But none of the faculties to which its glories bring joy can grow in the gloomy town where there is no sky to see.

CHAPTER II

FOG AND "STORM CLOUD"

WHEN air laden with unseen water vapour—as all air is to some extent—is cooled, it parts with its vapour in the form of mist, rain, fog, or dew. The temperature at which this takes place is known as the dew point for that moment; the warmer the air the more concealed moisture can be held in suspension in it.

Change from warmth to comparative cold is perpetually occurring everywhere; the alternations of day and night of themselves cause it; and currents of air, some warmer and damper than others, frequently meet and mix, causing part of the joint current to be cooled and give off its water vapour. The radiation of heat into space from the atmosphere and the earth is always going on with varying rapidity, producing cold and precipitating moisture. So that in town and country alike there will always be fog from time to

time; but fog clean, white, harmless, and likely to vanish easily under the rays of the sun. When great cities like London, Manchester, Newcastle, Glasgow, or Leeds are situated in river valleys, and themselves, by their many fires, intensify variations in temperature, there will be sure to be not infrequent fog.

But what happens when the early factory smoke and that from the fresh-lit kitchen fire is added to the fog which the chill of night has produced? We shall find that it is smoke that causes the evil of fogs. The mere fact that every particle of fog requires a tiny dust nucleus in the atmosphere round which to form, does not really affect the question, for in all parts of the atmosphere there is sufficient microscopic dust for this; even far out on the ocean or on the tops of the highest mountains water vapour finds sufficient dust round which to condense.

But smoke causes the evil of fogs in three different ways. First, solid particles of soot radiate heat much more quickly than other kinds of dust. "Most of us have probably noticed how much more quickly asphalt is wetted by dew than is stone or brick: the radiative power of lampblack is well known,

and this quality is not lost when the particles are scattered freely in the air; thus fogs are more rapidly formed and more persistently maintained in the presence of coal smoke, than in ordinary country air."[1] Therefore, in one way, by cooling the air, smoke produces fog, and when produced it is no longer white, but of the dirty yellow colour we know so well.

Secondly, particles of soot block the way of sunlight. Under the canopy of smoke the buried streets cannot be reached by the heat from overhead. Similarly, radiation is hindered and frost kept at bay.

Thirdly, the tarry substances in smoke cover every globule of water with a thin sheath of oily deposit, which apparently prevents its evaporation.[2]

The Meteorological Council, aided by the London County Council, made an elaborate study of the causes of London fog in 1902–3. They report that one fog in five is directly caused by smoke alone, and all the fogs are befouled and prolonged, and so changed

[1] Dr. Markel, at Manchester Conference on Beauty in Towns, 1905.

[2] These are the results of the long study of London fog made by the Hon. Rollo Russell.

as to become the great public curse of to-day.

At Christmas 1904 there were about four days of heavy black fog all over South Lancashire and in many other parts. It was a memorable fog. The city gas supply in Manchester gave out; people took a couple of hours to come in by train from the suburbs; the Christmas stock could not be sold by the dealers in provisions; people groped, and choked, and slipped in the dark streets, and at the end the money loss was counted up by tens of thousands. We told one another that all this was really avoidable, and the newspapers wrote sarcastic leaders to that effect. I was fortunate enough to be away at Grasmere at the time, skating on Easedale Tarn all day in clear winter sunshine, while that moisture which smoke in the towns had kept warm and made into fog by hindering radiation, was represented by the most wonderful hoar frost I have ever seen; the frozen crystals weighed down every bough and garden spray, and covered the walls by the roadsides an inch deep in icy crystals.

The Hon. Rollo Russell has made a calculation of the actual cost of smoke and fog to London each year: he took as a basis the one million houses and works of 1888, a number

which has enormously increased since then. He put down:[1]—

Waste of fuel, estimated at one-fourth .	£1,000,000
Extra washing and wear and tear of linen, &c.	2,150,000
Dresses, curtains, carpets, blinds, and other textile fabrics damaged and renewed	1,000,000
Increased mortality (valued on its economic side only), impairment of health, illness, and consequent expenses, reduced strength, hindered convalescence, lower vitality and working capacity	320,000
Total . . .	£4,470,000

He then puts down a million for the following numerous miscellaneous losses:—"Slow destruction of stonework (*e.g.* Westminster Abbey), granite, marble, &c., on public and private buildings, and cost of cleaning exteriors; destruction of mortar, cement, &c., making re-painting necessary (see Angus Smith on 'Air and Rain'); painting of houses inside and outside; restoring gilding, metal work, shop fronts, signs, names of streets, advertisements; restoring monuments, &c.; (*e.g.* Albert Memorial and drinking fountain in Great George Street); window cleaning, skylight cleaning, &c., including station roofs;

[1] "London Fog and Smoke" (P. S. King), p. 22.

replacement of blackened wall papers, &c.; depreciation or restoring of works of art, pictures, books, engravings, &c., in public and private collections; loss of time by artists, photographers, and other workers requiring daylight; extra labour owing to tarnishing of silver, &c.; damage to trees, plants, flowers, vegetables, fruit, in or near London; loss of time by delay of trains, &c.; accidents of all sorts, cost of fog signals, supervision of river traffic; extra gas, extra candles and lamps, both in dark fogs and in shortened morning and evening light throughout the year; extra fuel burnt owing to want of sunshine and loss of warmth; cost of chimney sweeping, cowls, light reflectors; absence from London of many of its richer citizens, and depreciation of house property." This category of losses has excited the attention of the Commissioners of Works, who have addressed a memorandum to Parliament on it.

The total comes to £5,470,000, which represents about £1 per head, and is not far from the cost of the coal used in London houses. It is impossible to remember many figures, but it may be easy for the reader to recollect that the smoke costs nearly as much as the coal. John Bright is reported to have said that a sunny day was worth a

million sterling to England. This estimate of solar energy may be more oratorical than mathematical; but the value must be very large.

The foggy haze also deprives what sunlight gets through of its efficiency and its heat. The fog inquirers of the Meteorological Council—Capt. Carpenter and Mr. Lempfert—had a system of burning-glasses to show what the real power of the sun was during two winter months. It was found that during December at Bunhill Row, E.C., 83 per cent. of the burning power was lost, and in Westminster 61 per cent.[1] The same inquirers found that the average distance to be seen from the summit of St. Paul's or the Westminster Palace Tower on a winter afternoon was only half a mile, due to the presence of a steady light haze made by smoke. For many winter months these two points were invisible one from the other. The block in aërial circulation caused by smoke keeps every kind of sulphurous and other impurity from being carried away. That is why the fog smarts in our eyes and chokes in our breathing tubes.

During a famous fog in London in 1880 some 3000 people more than usual died in

[1] Dr. W. N. Shaw, London Conference, 1905, p. 49.

three weeks, and the Hon. Rollo Russell estimates that 30,000 must have been ill from its effects.[1] A still worse case occurred in 1892, when after a heavy fog there were 1484 additional deaths in a week in London. A large part of this illness and death is caused by the soot passing into the breathing tubes and producing bronchitis; the delicate membranes of the lungs become clogged and inflamed with sticky soot, and so become diseased. Fog, indeed, may be regarded just as the means of bringing the effects of smoke home to us in a continuous and concentrated form.

When a town dweller is subjected to a post-mortem examination his lungs are found to be coal black in colour, and on microscopic examination, or even with the naked eye, they are seen to be full of minute particles of carbon. A cold fog will kill bronchial patients like a poison. The fog and smoke drive people to keep their windows and doors shut against it, and in the close atmosphere thereby produced consumption does its work.

Nor are the evil effects of smoke confined to temporary experiences of fog which leave behind them no permanent effect upon the weather.

[1] Hon. Rollo Russell on "London Fog," p. 20.

There are few men of the nineteenth century who, through a long life of leisure for such pursuits, have studied the clouds, the colour of the sky, and the effects of storm and wind, as did Ruskin. The Storm Cloud of the Nineteenth Century was a constant pre-occupation and a serious trouble to his later years. He delivered two lectures upon it at the Royal Institution, and the Brantwood diaries, published in the new Library Edition of his works, contain his notes concerning the disagreeable, dirty, choppy storm wind, bringing up shapeless, ugly, dull-coloured clouds, and darkening the days all over Western Europe. His numerous notes of sunsets and sunrisings, his wonderful descriptions of them, and his extraordinary faculty of minute observation, give him great claim on our trust in this matter; nor is it open to any one to say that he was unable to distinguish between fact and imagination. These things were written down in his diaries before ever his brain-power had been temporarily extinguished in delirium, and, even in the later and more invalid years of his life, the distinction between illness and health was always clear; and he remained when he was well, to the end of his life an entirely competent observer.

He says that the plague cloud began

gradually about 1871. Now it so happens that our accurate figures concerning the consumption of coal began in 1873 at 120,000,000 tons annually, and have now increased to 234,000,000 tons. I include the coal exported, for this is not an English, but a European phenomenon. During the same time Germany and Switzerland have been largely industrialised, and the same may be said in a much less degree of Italy and France. This expert, then, in the shape and colour of clouds, who lived and observed throughout the period of asserted atmospheric evolution, describes in his "Storm Cloud" the weather of his youth and maturity thus:—

"In fine weather the sky was either blue or clear in its light; the clouds, either white or golden, adding to, not abating, the lustre of the sky. In wet weather, there were two different species of clouds,—those of beneficent rain, which for distinction's sake I will call the non-electric rain-cloud, and those of storm, usually charged highly with electricity. The beneficent rain-cloud was indeed often extremely dull and grey for days together, but gracious nevertheless, felt to be doing good, and often to be delightful after drought; capable also of the most exquisite colouring

under certain conditions; and continually traversed in clearing by the rainbow; and, secondly, the storm-cloud, always majestic, often dazzlingly beautiful, and felt also to be beneficent in its own way, affecting the mass of the air with vital agitation, and purging it from the impurity of all morbific elements.

"Often in our English mornings, the rain-clouds in the dawn form soft level fields, which melt imperceptibly into the blue; or, when of less extent, gather into apparent bars, crossing the sheets of broader cloud above; and all these bathed throughout in an unspeakable light of pure rose-colour and purple and amber and blue, not shining but misty-soft; the barred masses, when seen nearer, found to be woven in tresses of cloud, like floss silk, looking as if each knot were a little swathe or sheaf of lighted rain. No clouds form such skies, none are so tender, various, inimitable. Turner himself never caught them. Correggio, putting out his whole strength, could have painted them—no other man."

Here is his first record of the plague wind, from *Fors Clavigera* (Letter viii.):—

"It is the first of July, and I sit down to write by the dismallest light that ever yet I wrote by; namely, the light of this

mid-summer morning, in mid-England (Matlock, Derbyshire), in the year 1871.

"For the sky is covered with grey cloud;—not rain-cloud, but a dry black veil, which no ray of sunshine can pierce; partly diffused in mist, feeble mist, enough to make distant objects unintelligible, yet without any substance, or wreathing, or colour of its own. And everywhere the leaves of the trees are shaking fitfully, as they do before a thunderstorm; only not violently, but enough to show the passing to and fro of a strange, bitter, blighting wind. Dismal enough, had it been the first morning of its kind that summer had sent. But during all this spring, in London, and at Oxford, through meagre March, through changelessly sullen April, through despondent May, and darkened June, morning after morning has come grey-shrouded thus. And it is a new thing to me, and a very dreadful one. I am fifty years old, and more; and since I was five, have gleaned the best hours of my life in the sun of spring and summer mornings; and I never saw such as these till now. It looks partly as if it were made of poisonous smoke; very possibly it may be: there are at least two hundred furnace chimneys in a square of two miles on every side of me."

The characteristics of the plague wind are that it brings darkness with it; that it is fitful and irregular, causing a general purposeless trembling of the foliage; that it comes from no particular quarter, but intermittently from several quarters in succession; that it blanches not reddens the sun if seen through it; that the clouds it brings are often a dirty brown, and generally shapeless and ragged. Ruskin never went beyond a single suggestion that it might perhaps be due to smoke; he does not seem to have been convinced about that; to his mind it appeared something like a visible form of heavenly displeasure for the sins of the modern world. But smoke it is, mixed with damp. Air currents meet the gaseous products of combustion, mixed with minute material particles, and are hindered or diverted in their course thereby, and move forward dirty, irregular, and scattered. It would appear as though the upper air did not always have time to become cleansed each day from the gases and carbon which rise into it: there is not enough free space at hand, and an unclean atmosphere blocks what was the serene expanse of the sky.

The evil has become in its totality too vast for local distinctions to be more than partial,

and merely local remedies effectual. Ruskin writes from Vevay, on the Lake of Geneva, so long ago as 1869:—

"I am writing where my work was begun thirty-five years ago,—within sight of the snows of the higher Alps. In that half of the permitted life of man, I have seen strange evil brought upon every scene that I best loved, or tried to make beloved by others. The light which once flushed those pale summits with its rose at dawn and purple at sunset, is now umbered and faint; the air which once inlaid the clefts of all their golden crags with azure is now defiled with languid coils of smoke, belched from worse than volcanic fires."[1]

In looking forward to the time when broad lands should be owned by the Guild of S. George, he wrote, "Over those fields of ours the winds of heaven shall be pure." But it is clear that they cannot be pure alone. It is only by purifying the air of all England that the Guild can carry out its Master's hope.

[1] "Queen of the Air," Introduction, p. viii.

CHAPTER III

COMBUSTION

THE useful part of coal consists of carbon and hydrogen compounds, and the heat results from burning the carbon and hydrogen; that is, combining them with oxygen from the air. Coal also contains some oxygen and nitrogen, and many impurities; minerals which appear in the ash, and sulphur, which goes to make the sulphuric acid of smoky atmospheres.

When the combustion, *i.e.* the union with the oxygen of the air, is perfect, the hydrogen joins with oxygen to form steam, and the carbon joins with the oxygen and makes carbonic acid gas (CO_2). In an ideal condition these two would go up the chimney along with nitrogen from the air and some other compounds. Carbonic acid is not directly poisonous; there are always at least three parts in ten thousand present in the atmosphere, and four in ten thousand in

towns. It is given out in our breath, by all animals and decaying matter, and it is the food of the leaves of plants when in sunlight. It is what causes the effervescence of aërated waters. Whilst it does not support life we take no harm from breathing it in the usual small quantities. The first application of heat to coal liberates the hydro-carbons —gases which burn with the smoky flame which appears when you put coal on a fire. The trouble with them is that they are produced at a lower temperature than that at which they can be burnt. To burn them completely, and so avoid smoke, a strong draught of air is needed, along with great heat for a sufficiently long time. If there is not air enough, the hydrogen takes all there is, and leaves the carbon behind in the smoke to form soot; if it is not entirely left behind, it is half burnt, making the poisonous gas carbon monoxide (CO); only one atom of oxygen instead of two joining an atom of carbon.

Then more slowly, the coke, the red part of the fire, burns, demanding a smaller supply of air.

Therefore we need to supply a varying amount of air; the most for a period of from three to five minutes immediately after

stoking a boiler. Moreover, the air should not be much more than is needed, or it cools the gases below the point where they burn, and also wastes the heat of the boiler. We must, therefore, have a hot furnace or combustion chamber where the gases are kept for a time sufficiently long to be thoroughly burnt.

It is to solve the problem presented by these conflicting requirements of great heat and ample but intermittent fresh air that engineers have addressed themselves. The most obvious and simple course is to provide a hot blast, and to stoke frequently, and only put on a little at a time. When a large quantity of fuel is put on at once it chills the heat of the previous fire, which is probably burning low, and it also causes the giving off of more hydro-carbons than there is air to burn. A great smoke follows, and continues till the two requisites for combustion, oxygen and heat, are again in the ascendant. This excess of hydro-carbons is exactly what arises when a lamp wick is raised too high and the lamp smokes. Too much oil is lighted for the available air to burn properly. The same follows if you take the lamp chimney off; there is no longer the draught of air which the chimney sets up,

and the flame becomes smoky at once for want of it.

If, however, a little coal can be sprinkled regularly on to a red-hot boiler fire, the heat is great enough to burn it, and the gases on their way up the furnace are subjected over the glowing fire to great heat for long enough to complete the process, and send steam and carbonic acid gas up the chimney, the latter constituting in complete combustion about 12 per cent. of the chimney gases; a large part of these is of course the nitrogen of the air. This demands an almost automatic exactitude and constant watchful care upon the part of the stoker, in a stoke-hole where supervision cannot be constant. This sketch of the process of combustion shows that the problem is a chemical as well as an engineering one; and that the boilers in any factory should be under the control of a chemist, and be constantly subject to his analysis of the chimney gases.

The waste of heat when through insufficient combustion the carbon is only partially burnt and carbon monoxide formed, is about three-quarters of what the heat might be. The heat produced by burning one pound of carbon to CO_2, or carbonic acid, is 14,647 British thermal units:

burning the same to CO only produces 4451 units.

Smoke consists not only of soot, but also of silicates and other mineral ash, and of what is the most pernicious part of all—hydrochloric and sulphurous acids, and tarry oils which give the fatal stickiness to the dirt deposited. Sir William Thiselton Dyer's figures give as the solid deposit at Kew nearly two tons per acre per annum.

The least harmful part of smoke except the steam is the carbonic acid. It is only when it is confined by a canopy of soot-laden fog that it fails to diffuse itself harmlessly in the atmosphere, and becomes too concentrated for health, causing depression and lowered vitality. It is not uncommon in a town fog to have the normal quantity of carbonic acid doubled. This is like breathing other people's breath.

The sulphur, which exists in small quantities of nearly 2 per cent. in coal, is also burnt, and goes into the atmosphere as sulphurous acid (SO_2). This is inevitable unless we first turn coal into gas, and then burn that. Coal loses its sulphur in the process of gas making. Even then much of it appears in the coke. This acid has always in it the possibility of mischief, but if it were

scattered freely into the air, it would do much less harm than it actually does, when mixed with and attached to the soot and tarry oils of the smoke. If free, it would be dissolved by rain, greatly diluted, and mostly washed away. In its present condition of mixture with soot it settles on buildings, iron railings, and the leaves of plants; it acquires another atom of oxygen, becomes sulphuric anhydride (SO_3), and then, joining with a molecule of water, becomes sulphuric acid (H_2SO_4), which at once corrodes the stone or iron of buildings or kills plants. Dr. Markel pointed out at the Smoke Conference of 1905 that this corrosive action is continuous and progressive, the acid acting as a means of bringing oxygen from the air, which it parts with to the iron, and then goes for more, producing ever more rust, weakening girders, and wearing away bridges.[1] Manchester air was found by the Air Analysis Committee in 1891 to contain fifty times as much sulphurous acid during winter as was found in a country place in Surrey. Dr. Rideal estimates that from half a million to a million tons of

[1] The acid and the iron make ferrous sulphate, which gathers oxygen from the air and becomes basic ferric-sulphate, which in contact with iron becomes ferrous sulphate again plus oxide of iron or rust. The process then starts again with the ferrous sulphate.

this pestilent destroyer are sent into the air of London every year, covering statues and buildings with a crust of sulphates, to which soot can stick.[1]

Sulphuretted hydrogen—the "main principle" of a rotten egg—also occurs in small quantities in half-consumed smoke. Dr. Cohen, of University College, Leeds, has discovered it in soot as well as in the clear gases. It is poisonous, tarnishes silver even when in minute traces, and destroys paint.

The larger part of the miscellaneous impurities finally settles among the soot as a dark-coloured, sticky oil, which Dr. Cohen found to be 15 per cent. of the total weight. This is why soot sticks to everything and leaves its mark; and why rain cannot thoroughly remove it. It is thickly deposited on a mature evergreen leaf in any town garden.

Many manufacturers consider that it is more economical to work with slight smoke than with none at all. The loss on smoke itself is not great, and the puff on the chimney-top shows that there is no excess of air, and consequent cooling and waste. That is, they prefer to err on the safe side of expense. This issue is not an immediately pressing

[1] Smoke Conference, 1905, p. 21.

one. We shall be for some time so occupied with the great transgressors, the blatant and reckless public enemies, that any one who watches with comfort a faint whiff at his chimney-top at stoking time will be left thankfully in peace. But it is the limiting case; and as our apparatus improves, an analysis of chimney gases, and an eye to the coal bill will surely give safer results, and keep a clean chimney. From that ideal we must not depart.

CHAPTER IV

THE DOMESTIC GRATE

SOME manufacturers are fond of saying that most of our smoke is due to domestic fires. Dr. D. N. Shaw estimates that 70 per cent. of the London smoke is domestic.[1] In the large manufacturing towns, or where mills or collieries abound, it is of course much less than this; while in such places as Cheltenham or Leamington or Southport, domestic smoke would account for nearly all. But then in these places the smoke nuisance is small. A Sunday morning walk in a manufacturing district, at a time when the mill chimneys are not in action, and the atmosphere relatively is clear and sunny, would support the belief that the factories cause more smoke than the cottages.

Dr. Crawshaw, of Ashton-under-Lyne, contributed an interesting observation to the *Manchester Guardian* of November 22,

[1] San. Inst. Congress, 1902.

1906. A heavy fall of snow occurred in the early hours one Christmas morning, which was a Friday. The mills were shut till the following Monday morning, and on Sunday afternoon the snow on the house-tops was almost as white as when it fell, even in spite of the smoke of all the Christmas cooking in the houses, and the warm fires kept up for a snowy Christmas time. By nine o'clock on Monday morning, when the factories had begun, the snow was thickly covered with particles of soot.

Observations were made some fifteen years ago in Manchester by Dr. Bailey for a Town Gardening Committee as to the local distribution of the soot-fall, and the opinion was expressed that it was heavier in the parts of the city where most dwellings are than in those where most factories are; but such an attempt to discriminate is apt to mislead, for there is no clear distinction between such localities in Manchester. The height of the factory chimneys leads the soot to be deposited a little further off, but none the less deposited in the end; and the central part of the city, where the smuts are very bad, is neither a residential nor a factory locality, but it naturally receives contributions from more smoke-producing

sources than anywhere else on account of its being in the midst of them.

It is, however, said that domestic smoke, being given off at a lower temperature than furnace smoke, contains more of the offensive oily compounds which stick, and are particularly fog-forming. But the relative clearness of the air on Sundays and public holidays is a forcible argument in the case against factories. The proportion between the two varies, of course, from place to place; but the proportion does not matter. It is the two together which make it an urgent question; and both must be attacked. But there is less to be said for the manufacturer than for the householder. We all have an equal need of the domestic hearth, but smoke-making manufacturers add to the dirt of their private chimneys an utterly disproportionate contribution to public damage. Moreover, the law is already on our side, and a groaning, half-articulate public opinion. I shall hope to show that the engineers have solved the factory problem, while the fireside is not yet completely curable unless by the new promise held out at the end of this chapter. We are bound, therefore, to press the more immediate hope first. Then

regulation will be more just, more practicable, and more successful than is at present the case in private houses. It was admitted by Sir George Armytage, the chairman, and Dr. Des Vœux, as witness before the Royal Commission on Coal Supplies (vol. ii. p. 184), that the waste of coal in London was nothing compared with that in the factory districts.

Included in the report of the Royal Commission is a calculation by Mr. Beilby that 36,000,000 tons out of 168,000,000 used in the country, or only 21.4 per cent. of our home consumption, is used in domestic fires. The Commissioners in their Report finally accept 32,000,000 tons, or 19.2 per cent., as approximately true.[1] House fires are not probably very much more smoky than boiler fires badly stoked in places where mechanical stokers or other preventive devices are not used. They may perhaps make over one-fourth of our total smoke—this can only be guessed at—but it is scattered everywhere over the country, and much of it delivered in small portions, too small to be an evil. It is therefore wrong to decline to take up the more practicable and the larger reform till we have cured the more obstinate remnant. Let them improve together. Domestic

[1] R. Com., vol. iii. p. 11.

smoke is urgent enough for reform, and much may be done, though we are faced with a heavy mass of habit, and with many vested interests in smoky firesides.

Surely the reward of the cost and trouble of this reform is well worth while—the reward of a clean town. But one has no reason to think that it will become general unless the pressure of authority is brought to bear; that is, unless the better public opinion can lift the less advanced. Meantime let those whose eyes are opened feel it to be part of their citizenship to make themselves centres of smoke consumption.[1]

There seems little reason why many of us should not burn coke; and if we yearn for flame sometimes, put a log of wood on the top. The coke is difficult to light, but this may be managed by bringing an iron gas-pipe with holes in below the fire, in the manner of a Bunsen burner. When this has been lit for ten minutes the fire is lighted for the day. There are no fumes, or dryness, or stuffiness. By this plan much expense is saved, for coke is cheap. There

[1] Those who incline to try anthracite stoves can obtain them from Ernest E. Pither, 36 Mortimer Street, London, W., whose smokeless kitchen ranges and water heaters are very well spoken of by their customers.

is no firewood to buy or chop, no trouble in lighting, no soot in the room, no chimney sweeping, the fire gives off heat immediately the gas is lighted, and a coke fire is a hot one. The late Sir Charles Cookson, C.B., K.C.M.G., had this plan in use for six years in the seven grates of all types in his house in Cheyne Walk, Chelsea, and strongly recommended it for the reasons above given.[1] The gas for lighting up cost him a halfpenny a week per fire. This appears to be one good way out of domestic smoke, and it will do with any grate that has a good draught and not too broad a chimney. A combination of coke with gas always turned on is a good one.

Of hot water boilers, the upright cylinders, with a coke fire in the middle and the hot water like a blanket all round it, are happily coming into general favour, which in my own experience they deserve. The use of the kitchen fire is thus reduced to little but cooking. Here gas cookers come in. They are popular with cooks. The kitchen is not made too hot to be good-tempered in. They are altogether a much neater and more civilised device than hauling up

[1] His paper is in the Report of the Smoke Conference, 1905.

boxes of coal and throwing them on a fire. They are becoming more and more popular every year. The gas companies alone have increased the number in use by 850,000 in ten years in London and twenty provincial towns. Thirty thousand are in use in Manchester, lent gratuitously by the Corporation, and 6000 fresh ones are added every year.

For passages, bedrooms, offices, consulting rooms, and all rooms only occasionally warmed, gas stoves are convenient and economical. One I have lately installed (Langfield, 237 Deansgate, Manchester), has a clever arrangement of pipes up the back communicating from below with the outer air, which bring in more fresh warm air the more you heat the stove; there is a pipe to take cold air out, and there is a simple evaporation tank attached to prevent undue drying of the air, if any one prefers to maintain this ancient superstition. In halls and dining-rooms coke stoves of the continental type might be used.

There remain the sitting-rooms for those who refuse coke or gas. An open coal fire will always smoke a little; but there are degrees. The Coal Smoke Abatement Society has instituted three series of long

and careful tests of grates.[1] At the series of tests in 1901 the most successful grates were, in order of merit, "The Florence" (London Warming and Ventilating Company, Ltd.); Helyear's Patent Tropic Grate; Peate's Patent Front Hob Fireplace (28 Berners Street, W.); Bowes' Patent Well Fire. The quality of this set of grates was about the same as the next set—the best not quite as good, but the last rather better than the last of the 1903 set.

At the tests in 1903 the best was one named "The Tropican," made by Chavasse and Kerr, of Birmingham; the second was one made by Messrs. Landers, Ltd., 8 Bradford Avenue, E.C.; the third, the "Heaped" fire (Bratt, Colbran, & Co.); the fourth, the "Francombe" (Clark, Hunt, & Co.). The tests were for smokelessness, economy, and heating power. It is most striking to note how the most economical is also the hottest and the freest from smoke, and *vice versâ*. The three tests are almost parallel if so arranged. This fact is supremely important, for what is true of combustion on a small domestic scale is true also on the large factory scale.

[1] Detailed reports may be obtained from the Society, 25 Victoria Street, S.W.

The third test was carried out in the winter of 1905–6 on a larger scale than the others. Forty or fifty grates were sent in for testing, and the greatest care was taken. The best for economy, heat, and smokelessness were adjudged to be those of Messrs. J. & R. Corker, Ltd., of Saracen's Head Buildings, Snow Hill, E.C. (the "Drawwell" grate); Messrs. Candy & Co., Ltd., of Heathfield Station, Newton Abbot, Devon (the "Devon" fire); and Messrs. Hendry and Pattison, of 11 Hills Place, Oxford Street, W. (Boyd's "Hygiastic" warm air grate). These three show practically equal results; and the "Florence" grate of the London Warming and Ventilating Company, also sold by Messrs. Smith & Wellstood, 7 Upper Thames Street, E.C., came very near to them.

There was one grate which did not do itself justice among the competitors at these tests, and it is not now manufactured; but I mention it here in the hope that some manufacturer may once more put it upon the market.

The Arnott grate was invented by Dr. Neil Arnott about seventy years ago. He refrained from patenting it in order that it might be of greater public benefit, but this

philanthropic desire has, oddly enough, resulted in no maker taking up an article in which he could not have an exclusive right. It would appear that the children of this world are in certain generations wiser than the children of light. It is an under-fed grate; the coal supply for the day is put into a box under the grate, whose floor bars are of course removed, and a screw forces up the coal to the top as it is needed. The fire is lighted in the usual way at the top, and may smoke just at first, but for the rest of the day newly-lighted coal sends its flames up through the hot part of the fire, which is always red and smokeless. It is a wonderful fire for staying in, and is very economical, and by covering the box with ornamental copper or other repoussé work, it may be made not unattractive. Mr. T. C. Horsfall, M.A., J.P., of Swanscoe Park, Macclesfield, has been an active public advocate of this grate, which he has used in his own house for twenty-seven years with great success. Any intending manufacturer would receive the needed information from him. The late Sir William Gull used these grates for more than twenty years, and considered them a solution to the smoke difficulty for

good-sized houses. Whilst it can never be a very cheap grate, it might, if made on a sufficiently large scale, be brought to a price low enough to enable it to sell freely.

The Marsh grate is one which was not included in the above tests, but when properly managed it is quite smokeless. It is on the down draught principle, and may be used for fire grates or for kitchen ranges. It was manufactured by Messrs. H. Leggott and Co., of Bradford, Yorkshire, but that firm has ceased to exist there. It is cheap and economical. It is the only grate I know which will serve all the purposes of a cottage kitchen fire. But the jurors of the 1882 Exhibition say that the top and front of the fire, where the draught enters, are apt to be cold, and the best of the combustion takes place at the back. Moreover the clay slab on which it depends breaks away, and is always of uncertain quality. The ideal grate, which will cook, heat water, and look cheerful, all without making smoke, and so solve the cottage fire difficulty, I do not yet know of. Larger houses can divide these functions, and do them all with little or no smoke.

At the Smoke Exhibition at South Kensington in 1882 the gold medal was awarded

to Messrs. Brown & Green, of Luton, Bedfordshire, and Finsbury Pavement, London, for a very successful under-fed grate, but the firm has now ceased to make it—a dispiriting conclusion. The need calls loudly for the inventor.

Good grates afford means of greatly diminishing the smoke nuisance in places where gas and coke are unobtainable. Domestic smoke in the country need not trouble us. The only unavoidable delay in reform is that due to the existence of so many bad but durable domestic grates, which forbid us to look for more than a gradual reform.

Not every one knows that a fire will light more quickly, and therefore make less smoke in the process, if the coal is laid with its grain vertical, pointing up the chimney. The material should be built up in a conical shape (see a letter by Mrs. Leo Grindon in *Manchester Courier*, March 4, 1907).

Another small point may be noted. When a local authority refuses to collect vegetable refuse the housewife without a garden must needs put them on the fire, where they make much smoke for a long time and spoil the fire afterwards.

The time is ripe for beginning the gradual grip of public control, the compulsory

inspection and rejection of grates, with a penalty for excessive domestic smoke. If central heating of houses by hot-water pipes or stoves were tolerable to the English mind, we are told that we should save half our 32,000,000 tons of coal. For it is estimated that the ordinary fire-grate wastes seven-eighths of its heat. Without pressing the accuracy of such estimates, we know that stoves are much more economical, and they or their equivalent will come into use as coal grows dearer.

Cheap gas would do much to stop smoke: if cooking and heating could be done more economically by gas than by coal, how great would be the change. Some profit is usually made on gas for the relief of rates. At best this is only taxing irregularly, by use of gas, not by rateable capacity. The owner of cottage property benefits at the expense of the large gas-user, and even if everybody used gas in proportion to his rate assessment there is nothing to be said financially for a plan by which the public, by paying its rates in an inconspicuous way in its gas bill, deceives itself into thinking that it does not pay them at all. Oddly enough, it has to pay income-tax on these factitious profits. This is far more than a mere inequality in this very unequal world. It is a public evil.

We have in gas ready to our hands a practical method of curing smoke. The man who uses gas instead of coal is causing so much less dirt and loss to the town. He ought not to pay an extra rate in his gas bill for doing this good to the public. He ought to pay less. This could be automatically achieved by selling gas at some trifle less than cost; to make a profit should be avoided by every gas committee, as a sin. In Plymouth, where gas is sold at 1s. 9d., gas fires and cookers are common, and the air is remarkably clear. In the neighbouring town of Devonport gas costs 2s. 6d., and is used less, and there is the usual smoke nuisance. Mr. Martin states that the ordinary kitchener only uses 4 per cent. of the heat it receives, and smokes besides.[1] It might be wholly abolished by gas at 1s. 6d. or 1s. 9d., where gas at 2s. 3d. is a little dearer than coal. This difference is often no more than is swallowed up by gas profits, and by paying to the corporations rates on their own gas-works, a piece of account-keeping back and forward which might be spared for the sake of public cleanliness.

One way of stimulating the use of gas for heating would be by charging for gas for all

[1] *Journal Society of Arts*, March 30, 1906, p. 536.

forms of heating the same rate as is now charged for heating for power. It is not easy to see why any difference has been made. There is much prejudice against gas stoves. They are said to be stuffy and to give off fumes. The zeal of the Coal Smoke Abatement Society produced in 1906, after a month's elaborate tests of twenty-five stoves, an authoritative report[1] on their cost and their gaseous products from which I quote the summary conclusion:—

"A properly-constructed gas stove, with a flue sufficiently large to carry away the products of combustion, although for constant work more costly than a coal fire, is quite as satisfactory from a hygienic point of view, and does not in any way vitiate the air of the room, nor does it produce any abnormal drying effect as is popularly supposed. . . . It is only in the very largest gas fires that the calorific value of the fuel burnt per hour approaches that obtained in coal fires, being in the majority of cases only about one-third. Of this calorific value a higher percentage is utilised in warming the air of the room in the best coal fires than in the gas fires, when once a steady temperature has been attained, the ratio being roughly 3 to 1 in favour of

[1] Obtainable for 3d. from 25 Victoria Street, S.W.

the coal fires. The percentage which is lost in the flue gases is, however, greater in the best coal than in the best gas fires. When the initial raising of the temperature of the rooms had been accomplished, and the fires had produced a fairly steady rise, the cost per hour for each degree of rise in temperature was about four times as great with the gas fires as with the coal.[1] This does not necessarily mean that gas is always more costly than coal; other factors must be considered, such as the rate at which the room is warmed. It was found that while the gas fires usually produced a fairly steady temperature in the rooms in from one to two hours, the coal fires took much longer. This is in favour of the gas fires. . . . Another point in favour of the gas fires is that they can be easily regulated and the heat of the room controlled in a way which is not possible with coal fires.

"Taking into consideration the amount of coal which must be burnt before a comfortable and steady warmth is produced, and also the amount which must be burnt after the fire is no longer required, the examiners think that even from the point of view of

[1] This is taking gas at 3s. and 3s. 1d. per 1000, and coal at London prices.

economy the gas would run the coal very closely for domestic uses, where it is seldom necessary to have a fire constantly burning for long periods. It is the lighting and letting out which makes the coal fire wasteful, whereas a gas fire can be lighted and turned out as required without unnecessary waste of fuel. They are also of the opinion that a properly-constructed gas fire has the advantage of a coal fire from a hygienic point of view, owing to the more equable temperature and the absence of dust and smoke. The flueless condensing gas fires, while very economical of gas, pour into the room a large quantity of carbon dioxide gas. With plenty of ventilation they would be very suitable for warming rooms or passages where no flue existed to which an ordinary gas fire might be connected. These stoves make the most economical use of the gas burnt, but this is due chiefly to the absence of a flue and the consequent losses through it. When, therefore, such stoves are provided with sufficient ventilation to keep the air pure the heat is carried away in the air-currents, and in such circumstances they would probably not be more economical than the ordinary stove provided with a flue. There is also the danger that if anything goes

wrong with the flame, and the combustion becomes imperfect, the poisonous products will be poured into the room instead of passing up the flue as in the case of the flue stoves."

Within a few months from the date of the publication of this book, there will be placed on the market a new invention, the discovery of one of our ablest engineers, and backed by a strong mass of expert opinion and financial support, which bids fair to make a revolution in the whole question of firing for domestic use and possibly for raising steam.

Mr. Thomas Parker, formerly of Wolverhampton, known among engineers for having built among other things the Overhead Railway at Liverpool several years ago, and for having electrified the Metropolitan Railway recently, has produced a substance which he has called Coalite, which promises to cure at any rate the domestic smoke evil at a blow. This will no doubt gradually render out of date much of the inquiry into fire-grates which occupies this chapter, but it will add redoubled force to the plea for legislative efficiency in the chapters which follow. Under this process coal of any quality is subjected to distillation at a low temperature, and is afterwards cooled by being steamed.

The process lasts one-fourth as long as it takes to make coke. By this method many valuable residuals are obtained which are destroyed in the ordinary gas manufacture. A valuable carbonite for the insulation of electrical apparatus is a bye-product; also petrol, benzine, pitch, and gas of twenty-five candle power; these valuable bye-products enable the final Coalite to be sold for the price at which the coal was bought. As it loses one-third or one-quarter of its weight in distillation, the price per ton is likely to be one-third or one-fourth more than the local price of coal; and the bulk correspondingly greater. But Coalite burns best under a slow draught, and itself burns slowly. The heat is not blown up the chimney, but radiates into the room usefully.

It is absolutely smokeless. It burns cheerfully with a small yellow flame, lights easily, and has a brown, heavy ash. It is clean to handle, light to lift, and looks rather like coke. There are no fumes, and there will never be any chimney sweeping, if it burns for a century. The chimney gases do not even soil a white ceiling, and require only a very narrow chimney. Thus far I describe it as I have seen it burning in fire-grates and kitchen ranges. Experiments as to heat

produced per penny of cost, with boilers, are now in progress, and are so far very encouraging.

An independent analysis shows that it contains 15 per cent. of volatile matter, or half that in the original coal, and yields 5 per cent. of ash, 1.1 per cent. of sulphur, and 2.4 per cent. of moisture.

The change which this invention may produce on the face of England is greater than the imagination can realise. It may revolutionise English life. As citizens we can only hope that it will pay better to produce it cheaply in vast quantities than dearer as a luxury for well-to-do householders.

The Coal Smoke Abatement Society have reported upon it that it produces a bright, lively fire with flame, that "it is absolutely smokeless, and an efficient remedy for the smoke nuisance."

CHAPTER V

HAND FIRING

We now approach the boiler and furnace fires of our factories—where smoke is made on a wholesale scale.

Conservative optimists tell us that after all a good hand stoker is as good as a mechanical invention. But for a regular automatic feed, a regular automaton must surely be the best workman; particularly when a human workman has to open the door and let in cold air each time he stokes. For some time to come we shall nevertheless have hand stokers, and even to use automatic machinery much care by the fireman is needed. Let us then give an intelligent man a chance of being a competent stoker, not overstrained. Let their work be paid as such skilled work should be; let a bounty be given on economy of fuel, a public certificate be awarded to those who have not been fined for making smoke for a year, and let the hours be shortened. These

men have to make up the fires before the factory begins, to stay oiling and doing odd jobs while it stops for meals, to remain after others have gone at night. Holidays for others are the times for overhauling engine and boiler, for doing repairs, and for cleaning flues; and the fires must not be let out on Sundays. These men are generally working about fourteen hours per day, most of Saturday, and part of Sunday; say an irregular eighty or ninety hours per week. They have themselves put it to me that they do eighty-four hours' work for fifty-six hours' pay. They eat among the coals, rarely have a dinner hour, and live their working life in the stoke-hole. They lift twenty tons per boiler per week, and they have generally a fixed wage and no pay for overtime. To overwork them, therefore, is cheap and very remunerative, and some almost incredible instances of day and night work are told. These statements do not cover all cases, of course; there are those who are paid for overtime; but this is believed to be generally a faithful picture.[1] We shall not be surprised to hear that 90 per cent. of the complaints

[1] See letters by Mrs. Higgs in the *Oldham Chronicle* for June 6, 1905, and neighbouring dates.

made against manufacturers in Glasgow are, according to the chief sanitary inspector, due to careless firing.[1]

Can we expect such hard-worked fellows to increase their labour by stoking every five minutes when every quarter of an hour can be made to serve? A system of relays of night watchmen who can stoke, thus giving a moderate day's work, would do much. Payment should be by the hour, and (oddly enough) meal time should be essential. That men can be had for the work as it is is no answer. The work as it is makes the smoke as it is.

I also suggest that the stoker, as well as his employer, be liable to a fine for making smoke, though clearly this can be evaded by agreement.

Training of stokers is carefully done—as we might have guessed—in trained Germany. The Prussian Government subsidises it as a branch of technical education.[2]

Along with hand firing may be used various contrivances for producing the desired intermittent draught by automatic machinery

[1] Sir J. Ure Primrose, Smoke Abatement Conference, 1905, p. 81.

[2] Paper by Commander Caborne, Smoke Abatement Conference, 1905, p. 59.

which is set in motion every time the furnace door is shut. These are cheaper than the large mechanical stokers, and may be added to hand-fed boilers at little expense. While they can hardly claim to be perfect cures, they are all means towards perfect combustion, economy, and diminished smoke. The answers to a circular sent round to smokeless firms in London reveal, as it happens, few mechanical stokers, but many appliances of this simpler kind. It is fair to add that the firms give great weight to careful hand firing, but Welsh coal was chiefly used, or even anthracite or coke, so that this opinion may not stand for ordinary coal. Mechanical stokers cannot deal with anthracite, and are not needed for it. The same is practically the case with the Welsh semi-anthracite.

I cannot attempt to name all or most of the devices, but I have heard good reports of the invention of Messrs. Broadbent, Islington Square, Salford, who have a cheap mechanism costing £12, for opening a sort of venetian blind in the furnace door. Sanger and Webster's Patent Automatic Smoke Burner (W. Ingham, Cromwell Buildings, Blackfriars Street, Manchester) is a device by which the closing of the furnace door

opens an air door into the chamber at the back of the bridge and keeps it open for the right period.[1]

More thorough are those devices which introduce a strong draught of hot air into the furnace all the time, thus combining the two necessities for complete combustion, sufficient and prolonged heat, and a strong enough draught of air. With these mechanisms it does not matter if the air is at times in excess, for it is hot already. If it were greatly in excess it would mean a certain waste of heat, which, though saved from chimney gases, would escape too quickly up the chimney. This cure is simple, thorough, and perfect in theory; it is very much cheaper than the mechanical stoker, and I incline to think that it will have large scope in the future. Of course, the hot blast of air has to be heated, but then all that heat tells on evaporation, and is not wasted if supplied in the right quantity. Hinchcliffe's patent, made by J. T. Thornton, of Paddock, Huddersfield, consists of a cast-iron oven in the firebox in which the air is super-

[1] Others, taken from the Coal Smoke Abatement Society's Report, are: The British Fuel Economiser, Martin's Patent Door, Richard's Forced Draught, Coles' Furnace Door, Cuddy's Tubular Bars, Johnson's Economiser, and Venetian Rocking Furnace.

heated and passed into the furnace. This claims to be a complete cure, and has passed some very convincing public tests.

One of the best of all the devices which I have seen was brought out lately on a small scale by Mr. W. R. Marshall, at the Victory Works, Chamber Road, Oldham. It is a simple plan for letting in a stream of very hot air at the front of the fire, and also at the bridge. The stream has a velocity of 1080 feet to 1200 feet per minute, and a temperature, there is reason to believe, of over 1200° F. The apparatus is simple in the extreme, and needs no oversight of any kind. It is like a superheater, and occupies the space at the back of the boiler where the superheaters usually are. The air is let into the flue at the back, and passes through a "U"-shaped pipe, and then by a second box into a pipe of larger bore, 6¼ inches in diameter, which passes the whole length of the horizontal flue, gaining heat all the time until it reaches the bridge and proceeds by two smaller pipes to each side of the fire door. This device is theoretically perfect, affording for the whole time of combustion plenty of air and a very high temperature. When these two requisites are combined in a strong

draught of heated air, one feels that the problem has been attacked on right lines. In the boiler house at Lees Brothers, Oldham, I watched a fire recklessly stoked, by way of experiment, when already full of green coal, and the result was a slight cloud of brown smoke for one minute from the chimney-top, which then ceased. With careful stoking, or in connection with an automatic stoker, this device ought to be nearly smokeless. It costs £60 per boiler. I examined the residual left in the horizontal flue before and after the use of this apparatus, and whilst before use it was chiefly carbon which ought to have been burnt, afterwards it was a brown ash which did not dirty the hands, and apparently contained no carbon. A letter from a manufacturer who is using it records that it has saved 10 per cent. of his coal bill, and has more than paid the initial cost by a year's coal economy.

A hot blast invention by Mr. Edward Brunner, of 7 Mosley Street, Manchester, will shortly be brought out. It has varieties which adapt it for locomotives also. Its experimental trials have been very encouraging.

Hot air blasts are particularly useful where poor coal is burnt, as is often the case at the pits.

The use of forced or induced draught adds a further power of control over the rate of combustion. When the draught can be adjusted the combustion can be made more nearly perfect. If this draught is used along with one of these methods of supplying hot air at the front or at the bridge there need be hardly any smoke, and no need for the costly and too conspicuous tall chimney, which is at present the most striking feature in our national architecture.

Mr. Joseph Crawford, in a paper read before the Manchester Association of Engineers on the 9th of March, 1907, says that with the mechanical draught induced by a fan about four times as much coal can be burnt per square foot of grate area as with the ordinary chimney draught; the fire can be made thicker on account of the greater intensity of the draught, and in consequence less cold air per pound of fuel is needed, the air passing more slowly through the thick fire than through the thin one, and by the very intensity of the draught combining more completely with the fuel. He says that it is usual to use up 24 tons of air for every ton of coal, whereas theoretically only 13 or 14 tons of air are needed for each ton of ordinary coal. More is in practice required

for dilution, because we cannot expect that every particle of oxygen will come into contact with a particle of carbon. He claims that with a fan 18 tons of air can be made to do instead of 24 tons; thus less wasted heat goes up the chimney. He states that one quarter of the heat produced generally goes up the chimney to produce the draught, but if the quantity of excess of air could be halved this would become one-eighth instead of one quarter. Against this the cost of driving the fan is trifling.

This apparatus is particularly useful for electric light stations, on which the greatest demands are made in times of darkness and fog. The same fog which creates the sudden demand for light also checks the chimney draught, for the water vapour in the fog is lighter than air, and therefore tends to lessen the difference between the weight of the air outside the chimney and that inside. It is on this difference that the chimney draught depends.

We turn now to mechanical stokers, admitted at the Royal Commission to be the most economical means of using raw coal. Mr. Stromeyer, chief engineer of the Manchester Steam Users' Association, considered that the economy was almost wholly in the

opportunity to use cheaper coal with them than with hand stokers.[1] He also stated that heat loss in smoke itself was small. Its chief economic significance is that it is a warning that imperfect combustion is going on.

The important report issued by those who conducted the well-known smoke tests in Paris from 1894 to 1897 states that hand firing cannot ever be entirely smokeless. For a minute at least after stoking there is likely to be smoke. Authorities agree that to attain the best boiler duty and to avoid smoke the fuel should be fed on to the front of the fire in small charges frequently, and the fire pushed back each time preparatory to stoking. This is turning the man into a coking stoker, and is a hot task and a hard one. We go on, therefore, by a natural transition to the more drastic machinery by which the firing is done by hands of iron, and the furnace door kept shut.

[1] R. Com., vol. ii. p. 167.

CHAPTER VI

MECHANICAL STOKERS

Of mechanical stokers there are three main types. Of these the oldest established is the ingenious coking stoker. The coal is fed automatically from a hopper at a rate which may be regulated, and in small quantities, on to bars which gradually move the fire backwards. By this means the fresh coal is always at the front, and the smoke and hydro-carbons from it have to pass the whole length of the red-hot fire, and are completely burnt. The gradual movement backwards is achieved by bars which slowly move backwards all together, carrying the fire with them, but return with a sharp movement, half of them at a time, so that only every alternate bar moves at once. This does not carry the fire forward. There are variations of this device by various makers. These stokers are very generally successful; they are economical and can be used

without appreciable smoke with gentle work of the boilers. Their price varies. I have heard of a very good one costing £135 per boiler, another costing £105, and another costing £80 to £90. They do not, however, permit, unless aided by artificial draught, of forcing the boilers and still remain always quite smokeless, but even then they are far better than no device at all. They save the frequent opening of the fire door, which lets in excess of air and cools the furnace. The clinkers and ash can be removed while the furnace is at work, and the constant movement of the bars prevents their becoming clogged. The type has been steadily improved for a generation, and is extensively used. If a hot blast, itself an economy, is added, and a fan for draught, success is assured, even under difficult circumstances.

Some of the best-known makers of coking stokers are :—

Messrs. T. & T. Vicars of Earlestown, Lancashire.
Messrs. Meldrum of Manchester.
Messrs. Cass of Bolton.
Messrs. Sinclair of Leith, N.B.
Messrs. Proctor of Burnley make a stoker combining both the sprinkler

and the coking methods, and are now introducing a purely coking stoker.

Mr. Bennis of Little Hulton, Bolton, long a maker of a well-known sprinkling stoker, has now a coking stoker on a new plan ready to bring out.

Messrs. Hodgkinson, Pendleton, Manchester.

The Auto Stoker, made at the Union Iron Works, Ashton-under-Lyne.

Messrs. M'Dougall, Chadderton, Oldham.

When great strain is put on a boiler it may be necessary to add a forced draught or an induced draught. Vicars, Meldrum, Bennis, and probably others provide, if desired, forced draught arrangements with their stokers. With a blast of hot air this makes an absolutely complete outfit, and coking stokers can always be fitted with a variety of draught arrangements. This type of stoker, in the form of a movable chain-grate common in America, is awarded the palm by Mr. Benjamin, an experienced smoke official. He writes: "With the complaint sometimes made, that stokers cannot be forced, I have no sympathy. With an ordinary inclined grate stoker under a horizontal

tubular boiler, I have forced a boiler to 75 per cent. above its rating, with practically no smoke, and with an evaporation of 8 lbs. of water per pound of bituminous slack. It all depends upon the draught and upon the intelligence of the fireman. Probably, however, none of us believe in forcing a boiler to this extent. It is bad for the boiler, bad for the stoker, and bad for the coal pile."[1]

Mr. Hall, in 1897, reported to the Steam Users' Association in Boston that mechanical stokers effected about 30 per cent. of economy in labour in large installations—the larger the installation the greater the economy—but that under this head of labour there was no economy in small installations. Mr. Benjamin states that one man can feed boilers giving 200 H.P. by hand, twice as much by good mechanical stokers, and three times as much with complete coal and ash handling equipments.

The Sprinklers have an arrangement by which the coal is thrown in succession and in small quantities to three different distances, thus preventing any part of the fire being black and smoky at any time. These stokers more easily meet a strain than the coking stokers, but they are not so perfectly or

[1] *American Machinist*, Oct. 20, 1906, p. 435.

certainly smokeless. Firemen have told me that they had to help the sprinklers a little to spread the coal. The large pieces cannot be thrown so far back as the smaller ones.

The Under-fed Stoker Company makes a stoker in which the coal, fed from the bottom, is completely burnt by the time it reaches the hot part of the fire at the top. The Murphy furnace, imported from America, is a variant on this principle. There are many such under-fed furnaces in America, where it is commonly used.

To detail the various devices and strong points of these splendid inventions, and to give many tests, would be futile here. Any intending customer would obtain such information more fully from the firms. All have a good record of success in saving both money and smoke.

The years 1889 to 1895 were active in smoke prevention. As the outcome of much labour and public agitation, a Committee for testing smoke prevention appliances was formed, with Mr. Herbert Fletcher of Bolton as hon. sec., and the Report of this Committee, which came out in 1895, contains the most careful and elaborate tests of all methods of steam raising which have yet been made. It may still be obtained from Mr. Fred. Scott,

of 6 Booth Street, Manchester, price five shillings. There are enshrined in tabular form the results of the enthusiastic labour of Mr. Fletcher, Mr Scott, and the engineers they employed. Hand firing, coking stokers, and sprinklers were all carefully tested under both ordinary and test conditions. Chimney gases were analysed and evaporation measured. Any manufacturer desiring to be economical and smokeless should obtain the Report, always remembering that the twelve years which have since passed have seen many improvements in the appliances.

By observing all day for nine long days the forest of chimneys which send up to a heavy sky the smoke of Oldham and Bolton, it was found that on the average each chimney smoked ten minutes in the hour. Every chimney was noted once a minute, and 250 of these cloudy minarets were observed; but the above average was based on 179, before later observations were taken. The firm working each chimney was communicated with, and the result showed an enormous gain in smokelessness where coking stokers were employed—particularly Cass's, Vicars's, the Thornliebank, and Meldrum's forced draught. There were twenty-one examples of Cass's stokers, whose average

smoke emission was only sixteen minutes per day of ten hours. The Report says concerning Cass's stokers that "they come not far short of standing at the head also in power and economy"—and, "six of them, along with a Scotch example[1] of a similar system, are far the best in the competition, both by water evaporated (close upon 12 lbs., including the economiser, per pound of carbon value in the coal), and by the proportion of carbonic acid in the waste gases (12¼ per cent.)." We may, therefore, conclude that this stoker, observed in so many examples, was the victorious machine in 1895. The sprinklers in that series showed results no better than hand firing. Of this latter many successful instances were given, which show that when watched, and on his mettle for a brief test, and particularly when in charge of one boiler only, a man can still do as well as a machine. But this gives no guarantee of what is likely to happen, unwatched, when it is dark, and the tired man has many boilers to feed, for the whole of weary days. But, in fact, the tests do show what happens. A certain careful fireman, in charge of one boiler, made only seventeen minutes smoke in a day; but when

[1] Thornliebank, Renfrewshire.

he had three boilers to feed, with the draught weaker and the coal dirtier, he made eighty-six minutes; and when, so far as he knew, unwatched, he made forty minutes with one boiler. These are eloquent facts about hand firing.

For smokelessness only Sinclair's stoker came out the best, smoking only for four minutes in the day, but it was behind those above mentioned in power and economy.

There are many other encouraging facts brought out by the Committee. At Brunner Mond's Chemical Works at Northwich, fifty boilers fitted with Vicars's stokers were found to be nearly smokeless, even when the gases were concentrated into three chimneys. At the same works, Mond gas combined with superheaters for furnace purposes was found capable of producing the highest temperatures needed without any smoke. This is important, for while it is sometimes conceded that steam can be raised without smoke, chemical manufacturers put in a special plea at times on the ground of necessity. As iron works and chemical works constitute the greatest difficulty, I will quote at some length from pp. 22, 23 of the Report on that point, showing that they can use gas greatly to their advantage.

"In some of the furnaces of chemical works, especially where coal is used as an ingredient of the mixture to be heated, as in the black ash furnace of an alkali works, much care is needed to prevent the emission of smoke; the Committee believe, however, that this may be done by a due admission of air at suitable places. There are also cases where a high degree of heat is required, and where a reducing atmosphere must be maintained in the furnace. This is the case in puddling furnaces, and in the re-heating furnaces of iron rolling mills. In these it has been thought impossible to avoid the emission of smoke, since, unless an excess of carbonaceous matter is present in the air of the furnace, much iron is burnt away. It is found, however, that the flame of a gas furnace fulfils the necessary condition. This is largely composed of carbon monoxide, which, while keeping up a reducing action in the furnace, burns without smoke.

"Almost the last work of their engineer, Mr. Parnell, before his death, was a visit to the iron and steel works in the neighbourhood of Glasgow, August 1890, where he reports that he saw, at the Pather Company's Works at Wishaw, a gas-fired puddling furnace on the Siemens and Head principle, of which he was

informed by the management that the results were in every way satisfactory; and the economies — compared with coal-fired furnaces—were as follows: Work done, 30 per cent. increase; loss of metal, 50 per cent. less; fuel used, 64 per cent. less; coal used per ton of iron made, including lighting up, 6 cwts. 0 qrs. 22 lbs., against 23 cwts. 3 qrs. 9 lbs.; fettling, 40 per cent. less; repairs, 60 per cent. less.

"The coal-fired furnaces were constantly pouring out dense columns of black smoke, whereas, with the new furnaces, during a visit of five hours, hardly a trace of smoke was discernible. At the Wishaw works of the Glasgow Iron and Steel Company was found a large heating furnace of steel ingots, with a bed measuring 30 ft. by 8 ft. internal, and seven doors. The furnace was heating 80 tons of blooms, 5 in. to 8 in. square, per shift, with 70 cwt. of fuel. Compared with grate furnaces, this showed a saving in fuel of 75 per cent. The furnace had a separate chimney, and showed no sign of smoke during a visit of about two hours. Arrangements were being made to fire some of the steam boilers by the gases from the producers. On this system a portion of the waste gases is returned to the gas-producer, and cannot be

used for steam boilers, so that the economies claimed have to be discounted in respect of this circumstance.

"Messrs. Nettlefolds, of Birmingham, replied to our inquiries as to their use of the Siemens gas puddling furnaces (old form): 'We have never used any other kind, and therefore cannot give you any particulars as to the cost of changing from one system to the other. The gas is under complete control, and the smoke can be avoided entirely, except in case of delay or mishap making it necessary to keep the balls in the furnace, when, of course, a smothering flame is used to avoid waste. A great deal, however, depends on the puddlers, and they can make a good deal of smoke if they like. We always make less smoke than our neighbours, and we always considered that these (gas) puddling furnaces were more economical than those in ordinary use.'

"Since that time the new form of Siemens furnace has become of great value to manufacturers of iron and steel, and its adoption in connection with the glassmaking and other industries is very extensive. The chief point of interest, however, to the Committee lies in the fact that the furnace is an appliance capable of working with a minimum of smoke

emission, and at the same time showing a great economy in fuel over the cruder methods of working.

"The Lancashire and Yorkshire Railway Works at Horwich afford an instance of smokeless steelmaking from pig iron, and its subsequent manufacture. The gas from the steelmaking and heating furnaces is supplied by Wilson gas-producers."

Branch committees in other towns worked along with the Manchester Committee. The Glasgow Report concludes: "Enough is known at present to enable steam users to work their boilers with a fair degree of economy and practically without smoke." The Sheffield investigators say that "smoke may be almost entirely prevented from steam boiler chimneys." The General Report concludes in its largest print: "A manufacturing district may be free from manufacturing smoke from steam boilers." Also: "The addition of suitable gear for combating the smoke nuisance results invariably in a gain to the consumers."

These are weighty words by the men who, of all men in England, have the best right to give a judgment.

Firemen are naturally severe critics of these devices, which place their craft in danger

I have asked them what they thought of them for that reason. Their replies are unintended compliments. Either the heat they produce is so great as to melt the bars, or to prevent the fireman approaching the fire, or they tempt the masters to use too cheap coal, as the mechanical stokers can deal with very common fuel.

There is a great weight of testimony to the effect that nearly all the smoke can be got rid of, with an actual saving; but that to attain absolute smokelessness may in some cases be an expense, as most sorts of perfection are. Doubtless we should become another race in another country if nine-tenths of our smoke were removed; but I think the State has the right to claim perfect cleanliness, whilst thankful that the principal part of the abatement only needs thought and care, and the remunerative investment of capital.

The question of the economy due to the complete combustion of fuel by mechanical stokers is important. It is, when all sources of economy are included, very great.

The actual calorific value of the unburnt carbon monoxide and hydro-carbons which come out of a smoky chimney is not so large as one might suppose. It is not more than about 4 per cent. of the

calorific value of the coal.[1] But there are other losses, due to imperfect combustion or wasteful ways of firing. There may be an enormous loss, due to free heat wasted in the chimney gases, or due to an excess of cold air at the furnace door, or to the radiation and conduction from boilers or from hot ashes, due to the boilers being badly set. To obtain over 70 per cent. of theoretical efficiency in a boiler is to be extremely successful. The engine can only turn about one-fifth of this into mechanical energy. Most of the rest goes in the exhaust steam.

To speak of a final 14 per cent. of efficiency is to speak of good plant under good management. Most actual steam plants, particularly small ones and old ones, do far less than this—indeed, almost indefinitely less. Mr. Beilby, formerly President of the Society of Chemical Industry, stated to the Royal Commission that the average efficiency is believed to be under 4 per cent., or less than a hundredweight's heat out of a ton of coal. It is about what a good kitchen range gives. Some of this loss is inevitable, but clearly there is vast room for improvement.

[1] Chief Engineer, Hamburg Smoke Prevention Society, 1902–3.

The late Mr. E. Hart stated that the waste due to imperfect methods of firing in London is 42 per cent. of the whole. The Royal Commission state that over the whole country 33 per cent. was wasted by bad firing.[1]

No generalisation is much use where the uses of heat and the circumstances of its production differ so widely. It is safe to say that the chronic making of black smoke through forcing boilers is a transgression against the public. Every one ought to provide enough boiler power for his business. The cases of occasional and intermittent forcing are more difficult to deal with. In these cases the chimney gases may be washed, or the resources of forced draught exploited, or superheated air be introduced at the back or front of the fire. If the law were effective, ways would be found over this difficulty. At present the convenience of the manufacturer is the first thing considered, and the public health and happiness give way to it.

Among the neatest and most efficient methods I have seen of producing great heat is that of the Schwartzkopf Syndicate at Haydock, near St. Helens. Their apparatus burns powdered coal-dust. The fine particles

[1] Vol. iii. p. 11.

are whisked into a hot brick chamber, and burnt completely at once as they float in the air. There is no waste and little dust; all the heat is utilised, the finely-divided fuel being exposed to very hot air all round it. It is delay in the process of combustion which produces all smoke. The apparatus required is small and very pretty, but a large brick chamber is required, in which combustion takes place. This process has a special service where very high temperatures are needed, as in all that furnace work, such as puddling, welding, and other metallurgical processes, which now cause the outpouring of smoke, declared to be particularly inevitable in each special case. The effect of fine subdivision is familiar to the gardener, the chemist, and the doctor. Of course the coal has to be previously ground, for which the Syndicate sells machines. Every kind of common dirty coal rubbish and slack can be used; the smaller the better, indeed. Slack costs tenpence a ton to prepare, small coal a little more. In the coal districts slack can be bought at four shillings a ton, and is not in great demand. The firm is at present selling powdered coal to its customers, delivered in Manchester at eight shillings per ton. This is not, however, intended to be

a permanent arrangement. It is about the price the owners of furnaces generally give for ordinary coal. I saw the apparatus at work annealing at the works of Richard Johnson & Nephew, Bradford Iron Works, Manchester. Mr. Turnbull, the manager, told me that when in continual use at its maximum efficiency it cost half as much as ordinary furnace firing. Three hundredweight of coal anneal certain wire where it used to take eight hundredweight, but there is some waste time when the furnace is empty. This apparatus obtained a bronze medal at the Smoke Prevention Exhibition organised by the Royal Sanitary Institute and Coal Smoke Abatement Society in 1905.

One great advantage of the system in large works is that it will use up the impracticable dust left by the other boiler fires. Thus we obtain one more much needed economy in fuel.

The Incandescent Heat Company, 24 Coleman Street, E.C., have just brought out a patent furnace (Smallwood's Patents) for annealing, but adaptable for all industrial purposes. It is too recent to have much more than high hopes to offer. It claims to be clean, economical, and, after the first hour or two, smokeless. I have a test

result before me in which a continuous close annealing furnace was fed for a week with three-quarters of a hundredweight per hour of coal, more than half slack, and maintained at a steady temperature of 1000° C. Its size was 56 square feet, with a grate area of 7.5 square feet.

I shall go on to speak of gas engines in the next chapter. But, in spite of their great economy, there is doubtless a future also for steam. Nothing goes so smoothly and causes so little wear and tear as a steam engine, with the new lubricating oils, which are forced under pressure upon the bearings. The efficiency figure, whether mechanical or thermal, is only part of the question. The actual fuel bill is a smaller part of the cost of power than one would think. I have before me a sheet of figures giving the experience of a firm who run Mond gas engines, which give one brake H.P. per hour for a total cost of three farthings (or one B.T.U. for a penny). But 55 per cent. of the cost is depreciation of machinery at 10 per cent. and of buildings at 7½ per cent. and additions; 9 per cent. is for repairs and renewals. The actual fuel in coal and oil is only responsible for 18 per cent. of the total cost. I conclude that

we shall be likely to need for some time mechanical means for curing smoke in steam boilers.

A new boiler with great claims has just been invented at St. Petersburg by a Russian named Schmidt, and tested at Creighton's works, but no verification of its high hopes is yet to hand.

Charles H. Benjamin, in a paper read before the American Society of Mechanical Engineers and published in the *American Machinist*, Oct. 20, 1906, states that smoke abatement is easy and profitable to the owner of the plant, but absolute prevention, with soft coal, is impossible. The bituminous soft coal of America is softer and smokier than ours. Still he would probably recognise how practicable it is to cure most of our smoke—but that it may cost in a few cases a little to make a perfect cure.

A more definitely English opinion of great authority is that of Mr. A. E. Fletcher, late Chief Inspector under the Alkali Acts, who included a statement about Smoke in his report for 1892 to the Local Government Board. He says:—

"In the case of a hand-fed furnace the supply of fuel is intermittent, while the supply of air is constant. Clearly, therefore,

the necessary proportion between the two cannot always be maintained. The disproportion is also the more aggravated by the bulk of the gases intermittently thrown off. When fresh coal is thrown on a bright and fierce fire the sudden burst of combustible gases chokes the flue, and in a measure checks the draught, diminishing the supply of air at the very time when it is most needed.

"This obviously points to the necessity of a constant supply of fuel, which can only be accomplished by mechanical means unless that fuel is gaseous.

"It may with confidence be asserted that consumers of coal in almost all kinds of furnaces have it now in their power to conform with the requirements of the Public Health Act, and prevent the discharge of black smoke from their chimneys. As a proof of this, one prominent instance can be mentioned of a large chemical works, where may be seen a row of fifty large Lancashire boilers, each with two furnaces, and an equal number of furnaces applied to other purposes than that of raising steam, making in all as many as two hundred fires. Till lately, a row of four chimneys poured out a mass of black smoke, which shrouded the whole district in

its pall; now they are smokeless as far as colour is concerned, and only fully burnt colourless gases are sent into the air.[1] The question as to the economic use of the coal was narrowly examined, and I am assured that a substantial saving of about 10 per cent. has been effected."

[1] These are doubtless Brunner Mond's works, alluded to on p. 81.

CHAPTER VII

GAS AND ELECTRICITY

THE Royal Commission on Coal Supplies states in its final report (vol. iii. p. 14), that:—

"Gas engines are now established as the most economical of heat motors, and it is said that if the average steam engine and boiler installation of to-day, with its *average* consumption of 5 lbs. of coal per H.P. hour, were entirely replaced by gas producers and gas engines the 53,000,000 tons of coal, which it is estimated by Mr. Beilby are consumed for power purposes at mines and factories, would be reduced to 11,000,000 tons. The possibility of this enormous economy seems to be established by the results of many trials by which it is proved that power can be generated by gas engines in almost any locality and on almost any scale with the consumption of 1 lb. of average slack per indicated H.P. per hour. The general introduction of gas

engines and the use of producer gas could not, therefore, fail to have an important effect upon our coal consumption.

"At the time when gas engines were restricted to the use of ordinary illuminating gas, the conditions under which they could be used were greatly limited, but even then considerable advances were made. The next step was the successful application of fuel gas made from coke or anthracite to the ordinary gas engine; but little real progress was made until the successful application of producer gas made from ordinary bituminous slack. Even now it cannot be said that the gas engine has reached its final stage of perfection, and there appears still to remain a large field for the attainment of increased efficiency both thermally and mechanically.

"According to the witnesses much economy of fuel results from the use of producer gas plants, but this depends on several conditions, especially their size and their load factor. The fullest economy is obtained in large plants of 4000 H.P. and upwards with recovery of bye-products, in which case the cost of the coal is balanced by the value of the bye-products: without recovery of the bye-products it does not pay to put down plant for bituminous coal of less than, say,

100 H.P. On the Continent small anthracite plants are put down of 10 H.P., and in this country some are in use of 20 H.P. Up to at least 100 H.P. anthracite or coke plants are the most economical, but as to plants beyond 100 H.P. the opinions of witnesses differ, some preferring anthracite plants up to 250 H.P."

The great economy of gas is due to the fact that the energy of expansion is produced by burning the fuel right in the cylinder, without passing through the long and wasteful process of evaporating water and using the pressure of the steam. Very good steam engines use 2 lbs. of coal per H.P. hour.

Gas engines are now being made of larger and larger size, with no serious limit, and the old difficulty of starting them has been met. Suction producer gas plants are rapidly winning their way. Messrs. Crossley state that by putting $\frac{3}{4}$ lb. of anthracite, costing less than $\frac{1}{10}$ of a penny per hr., into the generator you obtain one actual H.P. This is the cheapest form of power known. Tangyes make analogous claims. You can also use coke at 1 lb. per hr. for one brake H.P. under favourable test conditions. The makers of suction plant give their customers an actual

guarantee of one indicated H.P. for one-tenth of a penny per hour for fuel.

Nor ought we to ignore oil engines. The Diesel oil engine gives a thermal efficiency of 35 per cent., about the same as a very good gas engine.

The capital cost of boiler and steam engine is, speaking generally and roughly, about the same as that of gas plant and gas engine. But the latter, as we have seen, produces on the *average* five times the power from a given quantity of coal, from its higher thermal efficiency.

The question of gas is one of the most important and hopeful we can consider, both for power and for domestic use. Instead of carrying raw coal into trucks and out of them, along railways and roads, into cellars and out of them, with great labour, dirt, and waste at every point in its transfer, till the housemaid deposits it in a coal scuttle and its smoke appears above our roofs, the gas manufacturer turns it into gas, coke, tar, and sulphate of ammonia, and obtains for these all together three times the original value of the coal. Neither gas nor coke make smoke; tar makes dyes and many wonderful and beautiful things now made in Germany; and sulphate of ammonia is a valuable manure,

which ultimately makes bread. When made from slack, its price, which is very variable, may be somewhere about three-quarters that of the coal from which it is produced. Its average price may be put at about £12, 10s. per ton.

Gas, it is true, only retains about a quarter of the calorific power of the coal from which it is made, but it uses far more efficiently what it has. You turn it on and off when wanted, saving domestic labour in its most unattractive shape. But at the price charged for gas in most places, gas stoves and gas cookers are generally considered economical only where they are used occasionally, and are turned off when not wanted. It appears, however, generally agreed that gas at 1s. 6d. to 2s. per 1000 cubic feet can compete economically all day long with coal. The cost of fuel at the twenty-five Metropolitan electric light undertakings was found equal to gas at 2s. 1d. per 1000 cubic feet.

The South Metropolitan Gas Company, one of the premier companies in the kingdom, sells gas of 14 (a rather low) candle power, at 2s., and pays 5½ per cent. on a capital, the original shares of which have been written up to a value much higher than they cost. The return on all the real capital used as

shares, debentures, or premiums, is nearly 7½ per cent. If a town were working the business with the need to make 4 per cent. for interest and sinking fund on fresh capital used in the best ways now available, this price could be reduced to 1s. 9d. If coal carriage to London costs roughly about 5s. 6d. per ton by sea, and a ton in the works of that Company makes 11,000 feet of gas (10,000 is the usual figure allowed), this gives about 6d. per 1000 feet for carriage, and reduces gas made at the coalfields to 1s. 3d. Some allowance would have to be added to this on account of coke being cheaper also. But this approaches the price at Widnes, Lancashire, where Mr. Isaac Carr, the manager there, can sell good 17 candle-power gas for 1s. 3d. to ordinary consumers, with a reduction on quantity, and at no more than 11d. for power. This, the lowest of all municipal figures, is reached in spite of the payment of 1½d. per 1000 feet to the relief of rates—an utterly indefensible plan, particularly in a smoky place like Widnes. Sheffield has also the very low rate of 1s. 4d. per 1000, with a reduction on quantity, and 1s. for power. At these places they have an excellent market for coke, and so make on residuals about 10d. per 1000 feet of gas. There seems to be no reason

why, at all places near coalfields, that is, over all the smokiest part of England, gas could not be sold at a little more than 1s. 6d. per 1000 cubic feet, or from that to 2s. where residuals have to go cheap.

A bold plan for supplying London with light, heat, and power by gas made at the pits' mouth, and transported in mains under 500 lbs. pressure per square inch, has been put forward by Mr. Arthur J. Martin in three papers,[1] to which I am indebted for many facts about gas. I give no opinion on the scheme, but if the difficulty of leakage can be overcome, there seems no other obstacle in the way of delivering gas in London for all purposes at 1s. or less per 1000 cubic feet. The actual cost of compression and transmission is worked out by Mr. Martin at from ¾d. to 1½d. per 1000. It is here that the economy comes in, for, if one thinks about it, it is a surprisingly cumbrous process to haul raw coal all over England—dirty, heavy, wasteful—when it might be transformed into four useful products at the pits' mouth, and thence more easily carried to where they are wanted.

[1] *Journal of Society of Arts*, March 30, 1906; *Proc. British Assoc.*, 1906; and pamphlet on "How to Prevent Smoky Fogs" (Sanitary Publishing Company, 5 Fetter Lane, E.C.).

This gas might be made from the slack and waste coal every year piled up round the pits' mouths or left in the workings, which is worth too little to bear the cost of removal. Every year, Mr. Martin believes, twice as much coal as the county of London uses is wasted in this primitive way, brought to the surface and left there. At the collieries also would naturally be concentrated the subsidiary industries connected with tar. If water gas were made by the exhaust steam from the compressor engines, and if, in the same neighbourhoods where coke is made, instead of the incredibly wasteful bee-hive coke ovens still in common use, bye-product ovens were used to collect the gases, precious for use and noxious when wasted, there would be a source of light or of power available for manufacturing purposes. Thus by the co-ordination of all the coal-consuming businesses near the collieries, utilising the waste of one business as material for the next, a powerful chain of economies can be set up. Many authorities prefer a central situation, accessible from several collieries, to a location close by one.

The plan of making power and distributing it over large areas, either as electrical energy or as power gas, is already one of our

established novelties. The large stations are more easily kept smokeless than a multitude of small plants; and this may be the chief method by which our air may be finally restored to us. Curiously enough, it was anticipated by Ruskin in a brief allusion a long generation ago. The Lancashire Electric Power Company is one of these distributing companies, and one of its customers is the Acme Spinning Mill at Pendlebury, which is worked wholly by electricity. The experiment is too recent to estimate its economic value as yet, but it may be the herald of revolutionary changes. Similar powers have been obtained by companies in Flintshire and East Denbigh, in South Wales, in the Durham and Newcastle district, in the Clyde valley, in Derby and Notts, in Staffordshire, in Belfast, and the West Riding of Yorkshire. The present difficulties of the South Staffordshire Mond Gas Company seem to be of a commercial, rather than of a scientific or manufacturing, character. The undertaking in West Cumberland is wisely arranging to utilise the waste gases from the blast furnaces, and expects to purify them and make a power gas, either for direct use or for driving dynamos. The cost of power will, they hope, be 15s.

per H.P. per annum, or one-third the cost of power at Niagara. That is a mere prophecy at present. The Royal Commissioners were much impressed by the economy made by utilising blast furnace waste gases for power, with or without electricity. They state that 10 H.P. is wasted in gases for every ton of pig iron made.[1] The plan succeeds in Belgium and Germany.

There are many testimonies to the economy of electrical power. Vickers, Son and Maxim at Barrow save 10 per cent. on their coal bill thereby, and at the same time gain 40 per cent. of power. In the Denaby and Cadeby Collieries two boilers suffice for what formerly took six. Messrs. Crossley say that one unit of electricity can be produced for a fuel cost of ½d. per hour with town's gas at 2s., or for ¼d. an hour with suction gas, with coal at 25s. per ton.

There is a difference of opinion among gas experts as to whether ordinary gas cheaply made, with a low light power, has a correspondingly low heat power. Most of the authorities, led by Sir George Livesey, think that cheaper gas, with a low candle power, is more economical as a heat producer. Mr. Carr of Widnes takes the other

[1] *Royal Commission Report*, vol. ii. pp. 13, 14.

view, thinking that the heat varies with the light. Mr. Newbigging, the Gas Engineer of the corporation of Manchester, believes that, within certain limits of candle power, there is not much in it either way, from the point of view of cost of heat. I have neither space nor knowledge nor wish to adjudge the prize among the competing qualities of gas—enough to know that there is a choice of cheap and smokeless heat-producers in the various forms of gas. It is all a question of price. It is stated by good authorities that Mond gas at 4d. is as cheap as illuminating gas of moderate candle power at 1s. 5d. The South Staffordshire Mond Gas Company at Dudley Port sells gas at 2½d. to 4d. per 1000, according to quantity. The evidence before the Royal Commission was, that where the Mond gas is made on a scale large enough to recover sulphate of ammonia profitably, it costs half as much as coal. The strongest point in favour of Mond gas is that it yields four times as much sulphate of ammonia per ton of coal as ordinary gas does. But it is stated not to pay to recover this, except on a large scale. These various gases are all our very good friends, and it would be well if they could all be sold by corporations at a little below cost, for reasons of justice stated

in Chap. IV. Moreover, the very fact of cheapening the gas would increase the demand, diminish cost thereby, and swamp some or all of the loss. For you have your rent, your plant, your management to pay for on a smaller or a larger output. Moreover, the extra demand induced for power or for cooking is a summer demand, no less than a winter one, and it is a daylight demand. It just comes when the demand for light is not straining the resources of the works, and so would most economically fill up slack times. Herein often lies the secret of profit.

Further, if pipe lines of power, whether gas or electrical, intersected England, instead of railways carrying long trains of coal trucks, the pipe line could be tapped anywhere, decentralisation of industries would be assisted, and Garden Cities promoted.

The smoke made in the aggregate by locomotives is a serious addition to our dirt. A locomotive uses 3½ tons of coal per day on an average, and scatters the smoke of 36 lbs. of coal over every mile on fast trains. Their furnaces are primitive, and do not attempt complete combustion. Some such device as that in hand by Mr. Brunner, 7 Mosley Street, Manchester, which

introduces a hot blast at the front of the fire, might be used. Or Mr. Martin's idea of carrying in the space now used by the boiler enough compressed gas to carry one hundred miles would cure it. And if gas were made at the collieries fewer trains would run.

Of all forms of heating, pottery ovens are, one would suppose, most in need of that efficient control of temperature, that uniform distribution of it, and that cleanliness in firing, which gas provides. They are also, in the common wasteful form of coal burning, among the smokiest of our nuisances. The potteries make a blot of blackness in the north corner of Staffordshire, and the roughness of their grimy population now and again comes prominently before the public. Mr. W. F. Murray (Todhills by Stevenston, N.B.) has spent many active years and much money in experiments on a large scale with ovens heated by gas, which have been crowned with success. His paper on "The Pottery Oven of the Future" is in the *Transactions of the English Ceramic Society*, vol. vi., 1906–7, and is reprinted by Hughes & Harber, Longton, Staffs. It is full of technical detail, and is well worth

study by any potter. It tells of enormous economies realised in fuel, in wear and tear, in diminution of breakages and spoilt goods. Gas is quicker in operation and easier to manage by firemen than is coal; and there are no insuperable obstacles to converting the existing ovens. At Messrs. Meakins' works at Tunstall gas has been successfully installed. At Glenboig for twenty years bricks have been successfully fired by gas. Everyone in the business seems to anticipate that this method of firing is sure to come. A drastic smoke law in the Potteries would henceforth be entirely just, and would save both the money and the atmosphere of that now dreadful district.

Gas is not a substance which, at first sight, would rouse one to missionary zeal or a whole-hearted enthusiasm; but I have come to look upon its modest flame with great respect. It means organised science applied to industry for the benefit of civilisation—it stands for economy and cleanliness, instead of smoke, coal dust, and barbaric waste.

CHAPTER VIII

SOME EXPERIENCES

It is not uninstructive that three firms, noted all over the industrial world for their many agencies for the betterment of their workpeople, have all taken special measures to make their works free from smoke. They have shown a noble and enlightened example, and we hope are the forerunners of many imitators. I allude to Cadbury Brothers at Bournville, Birmingham; Rowntree & Co., at York; and Joseph Crosfield & Sons, at Warrington. Two of these firms have built model villages, and there can be no model village under a smoking factory chimney. Let us hope that the clear air which is preserved by these pioneer firms may be recognised generally as part of the demand of that new and wider industrial morality which they have initiated. Let me detail their experience for the instruction in it.

Messrs. Cadbury Brothers have in their works Mond Gas, Vicars's stokers, and hand-firing. They incline to extend by installing the newest steam plant. Their chimneys are perfectly smokeless, the firm being determined to make no smoke in Bournville at any cost. They do not claim as yet that it is economical to do this from a purely fuel point of view. It costs something. Their hand-firing is smokeless only by allowing an excess of air; and they are not obliged to strain their boiler power. Their boilers are so scattered—being set up as the works have grown—that mechanical stokers do not save them much labour. They believe that their hollow fire-bars, though smokeless, let in rather too much air. Their Mond gas plant would be more economical if they collected the sulphate of ammonia; but this is said by some authorities not to be remunerative when done with less than 3000 H.P. plant. They find that 2 lbs. of coal produce one brake H.P. with their Mond gas plant. They hope ultimately to be smokeless and economical also.

Messrs. Rowntree had a difficult problem. Their boilers are fitted with Bennis compressed air and sprinkling stokers. These

are quite efficient, but under their circumstances they find it best to work their boilers as hard as possible, burning coal at an average rate of 32 lbs. per square foot of grate area per hour. The coal used is the cheapest grade of Yorkshire pea-slack, and contains a very large percentage of dust. In spite of the poor quality of the coal, the mechanical stokers have reduced the amount of smoke very considerably, but, owing to the dusty nature of the fuel and the high draught which has to be maintained, a quantity of small shaly particles left the chimney-top. This grit constituted more of a nuisance than the comparatively small amount of carbonaceous smoke which remained in the gases. In order to remove it they have built a large chamber through which the gases pass. Here all the grit and a large part of the sulphur compounds are washed out. Including interest on capital, this only adds about 10 per cent. to the cost of the coal, but a large supply of water is needed. It is hoped that by carrying the experiment further the volume of water may be reduced and the gases still further cleansed.[1]

[1] See the paper read before the British Association at York in 1906, by S. H. Davies, M.Sc., the chemist, and F. G. Fryer, A.M.I.M.E., the engineer of the firm.

The flue gases at the "down-take" of the boiler contain from 12 to 15 per cent. of CO_2 —an excellent figure. About 9000 lbs. of water are evaporated per boiler per hour. With coal of a calorific value of 12,500 B.T.U.'s, and allowing for the additional energy value of steam superheated to 520° F., they evaporate 10.45 lbs. of water per lb. of coal "from and at 210° F." under *test* conditions, or 9.06 lbs. under *average working* conditions. The final and most valuable figure is that of cost. In 1906, with coal at 6s. 2d., the cost of evaporating 1000 gallons of water and superheating the steam was 3s. 4d. in coal. Notwithstanding the high efficiency of their steam plant, and consequent low evaporation costs, they have found it more economical, in extending their plant, to adopt gas producers and generate power in large gas engines. Owing largely to the superior efficiency of the gas engine over the steam engine, there is a striking economy effected in the coal bill; with the gas plant only 1¼ lbs. of coal is consumed per B.H.P., whereas with the steam plant from 2½ to 3½ lbs. is required.

Crosfields' do not work their boilers so hard as Rowntrees'. They have a row of twenty-three boilers fitted with Vicars's

coking stokers. They only use 20 lbs. of coal per square foot of grate area. They achieve smokelessness nearly all the time, and save a thousand tons of coal per week, or £25,000 a year, compared with their unregenerate days. This sum includes economies on labour and in prolonging the lives of boilers. They lay emphasis on the necessity for a chemical staff to attend to fuel matters. They have received so many inquiries that they have established a professional department which will advise manufacturers who wish to abolish smoke and economise fuel, and will set up plant suitable for each situation.[1] Their case may be taken as a normal one where a steady demand for steam is made. Their figures are:—Coal at 6s. 3d. per ton; 9½ to 10 lbs. of water are evaporated, "from and at 212°," per lb. of coal with a calorific value of 11,700 B.T.U.'s; 7200 lbs. of water are evaporated per hour per boiler; and the percentage of CO_2 in the chimney is about 14. They take the hardness out of the water before using it, and send it in clean, which saves the boilers. After twelve years'

[1] The Fuel-Saving and Water-Treating Co., 2 Booth Street, Albert Square, Manchester.

work the inspectors of the National Boiler Insurance Association report a total depreciation of only 10 per cent. They believe they treble the ordinary life of a boiler. The boilers are worked night and day, and the upkeep amounts to 5s. per boiler per week. Gases leave the chimney at about 400° F. The perfect combustion of 12 tons of air with 1 ton of Lancashire coal would give 17 per cent. of CO_2 in the chimney; but it is impossible to reach this standard and maintain sufficient draught. Eight per cent. of CO_2 is a very usual figure. This results from burning 1 ton of coal and 28 tons of air. Steam jets carefully placed play on the bars underneath to prevent them burning. They have a special way of setting their boilers so that the gases travel the length of the boiler three times, and then through the superheating chamber twice before they pass up the chimney.

A very complete and successful system of smoke prevention is in use at the mills of Messrs. Fothergill & Harvey, at Littleborough, near Rochdale, installed by Mr. G. C. Storie of Rochdale as engineer. It consists of the Auto Coking Stoker, made by the Union Iron Co. of Ashton-under-Lyne; a fan giving an induced draught; and the hot-blast system

of Ellis & Eaves, made by Davy Brothers, Sheffield. The cold air enters among a stack of small pipes, in the inside of which are the chimney gases on their way from the boiler. The air is conveyed by two large tubes to the front of the fires, and enters below the fire-bars at a temperature of 300° F. This gives a perfectly clean chimney when in working order; and, of course, heat is saved from the waste gases, which are reduced, on the average, to a temperature of 295° F. at the base of the chimney. The boilers are hard-worked; 27 lbs. of coal per square foot of grate area are burnt, yet the four chimneys of the firm, once very smoky, now show an excellent example of smokelessness to a moorland district which might be very beautiful. One of these chimneys is from dye-works boilers. Here sudden irregular calls for steam are made. Magistrates are apt to accept the plea of necessity from dyers; but here there is never any smoke with the Auto stokers and the fan, except for a minute when the cinders are being removed. The fires never need poking. The hot blast is not installed to these boilers. I saw one of the firm's chimneys when there was no fan in use; a very small amount of smoke was then made for a short time at intervals, showing that the

mechanical stoker alone is a cure for most, but not quite all our smoke.

These examples show that in ordinary cases like Crosfields', practical smokelessness and economy can be achieved together by a combination of intelligence and goodwill; and that in a difficult case like Rowntrees', the same efforts produce a great abatement of smoke, and, at a moderate additional expense, perfect smokelessness.

Robert H. Buckley & Sons, cotton spinners, Mossley, Lancashire, use auto-stokers, which are practically smokeless, and save each year 10 per cent. of their cost. Mr. Fletcher, Paper Mills, Stoneclough, Kearsley, Lancashire, has a successful and very economical method of his own, which he is willing to show freely.

These are only a few typical cases; and the list, I am aware, might be very much increased, of firms who have overcome, or are overcoming, the smoke difficulty. They show that it can be achieved, but that it is a delicate matter, and its achievement something of a triumph.

CHAPTER IX

THE LAW

THE law is full of irregularity and of loop-holes. The Public Health Act of 1875 legislates with the utmost correctness against smoky chimneys, but inserts words about consuming smoke "as far as practicable," which, in practice, nullify to a large extent the effectiveness of the clause for obtaining convictions. If, as we believe, there is no necessity for manufacturing smoke if proper appliances are properly used, the words should be left out. It is usual for the prosecution to abandon this section as useless and to fall back upon another sub-section, which speaks of "any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance." There are two loop-holes here. In daylight no smoke looks absolutely and truly black, and it is left to the judgment of a sympathetic magistrate

to say whether the particular smoke is legally "black"; the most objectionable smoke need not be nearly black. Then the word "nuisance" is open to loose interpretation also. It is suggested that the clause should run "black smoke or smoke in such quantity as to be a nuisance." "Any person aggrieved or any two inhabitant householders" can give information of a nuisance to the local authority; and any individual who is not satisfied with the action of the local authority can try to convince the Local Government Board that this neglect exists. Many municipalities work under private Acts of their own, either made to suit the manufacturers, or drastic like those of Nottingham, the city of clean lace, where there are no phrases about "as far as practicable," and where the stoker, instead of the manufacturer, may be fined if the smoke is his fault, as is done under the Alkali Acts. Five minutes smoke per day is allowed at Nottingham. The law should be unified, and perhaps some attempt at the imposition of a uniform time limit for smoke may be made. We have no such limit in the general Public Health Act, and the authorities make one for themselves, varying from two minutes per half-hour in Manchester to fifteen minutes per hour at

Middlesborough. Many, however, think it dangerous for the law to sanction a time at all. The penalties also vary irrationally and unfairly from place to place.

More use should be made of the powers which exist to order the compulsory installation of smoke prevention appliances. This implies competent advisers in the Public Health Departments; and there is no reason why the State should not give sympathetic gratuitous advice and guidance to a smoke-producing manufacturer of good intentions.

This brings us to the largest question of all. It is plain that, as a whole, our Acts are not carried out; they are a dead letter in many of the worst districts, and only an occasional irritant in others. The reasons are not far to seek. The inspectors are under local control, are receiving weekly wages but little above those of a skilled workman; the firms to be watched are influential on the sanitary authority and the judicial bench of the district. They are wealthy and the inspector poor. The motive power of public opinion cannot concentrate, except in a few large towns, and all we can comfort ourselves with hitherto are partially successful efforts here and there, especially in London,

and isolated cases of complete voluntary smokelessness.

Many, probably all, reformers are agreed that smoke should be put under the Alkali Act, or a similar law, along with other noxious fumes. These Acts are administered by inspectors appointed by the central government, who have already done much in their own department. There should be in charge of large areas a sympathetic man of good scientific training, who would temper his powers by affording guidance to willing inquirers.

The law should also begin its supervision of the smoke of private houses in some gradual and moderate fashion. Every fire-grate should be inspected as drains are.

Why should not those dignified, and often leisured, persons, the police, whose monotonous patrols must be tiresome in an orderly city, become the rank and file of the smoke inspectors? They change their beats, and a given chimney is visible to many, so corruption is difficult, and confirmation easy. Surely they could effectively inspect, under a highly qualified head, at no extra cost. They are about at all times of the day when the inspector is in bed or at lunch.

Germany has no general law on smoke. But the city of Dresden has regulations

against "smoke containing visible particles of soot constantly emitted"—an excellent form of speech. They take a moderate control of private dwellings, enacting that the heating "must be so contrived as to produce as little smoke as possible." They have, further, an inspector whose duty it is to assist all citizens as well as coerce them, and who provides gratuitous instruction in stoking. This paternal and helpful control and complete grip of all smoke might be a model for our towns.

The London Coal Smoke Abatement Society, 25 Victoria Street, Westminster, has sent round a series of questions to Sanitary Authorities, the replies to which constitute a strong body of representative opinion. Thirty authorities report that they have entirely neglected the matter. So, we may infer, have many others who have not sent any reply. These centres of indifference include such smoky places as Crewe, Darlington, Devonport, South Shields, Wednesbury, and West Bromwich. It is painful to reflect that for these thirty years the Local Government Board has nominally had the duty of compelling such places to action on complaint being made, but has ignored its powers or found them too weak.

Many places report that they utilise the services of the police to report smoke, and Nottingham recommends that the law shall make this a special duty of theirs everywhere.

Twenty-four authorities think the smoke evil is increasing, forty that it is unchanged, eighty that it is decreasing.

The startling thing is that only in London and in seven provincial towns are prosecutions undertaken to any extent that matters. These towns are happily large ones, and they are arranged in order of the number of prosecutions in two years:—Liverpool, 1258; Manchester, 277; Glasgow, 226; Birmingham, 178; Bradford, 111; London, 91; Nottingham, 69; Sheffield, 62. There were only 164 prosecutions in all initiated by the remaining 102 authorities in two years, although they had received 6182 official reports of black smoke nuisances. This is evidence of inefficiency. The legal process is slow and cumbrous, and necessitates a warning notice before action each time. Several authorities state openly that the magistrates before whom the cases would come are themselves offenders. Several demand that these cases should go before the Stipendiary, who is not a manufacturer. Only two authorities state their satisfaction with the law as it stands.

The word "black" is found to be a stumbling-block by many, and various suggestions are made. Higher penalties and cumulative ones are widely asked for, and a more prompt procedure dispensing with the need for a statutory notice is advocated by many places. The whole return is of the deepest interest.[1]

Only twenty-two places employ special smoke inspectors. Manchester heads the list with five. There should always be such an official. The ordinary sanitary inspector is not a chemist nor an engineer.

The London Smoke Abatement Society finds that when any London borough makes up its mind to stop smoke it can do so.

Dr. Cohen tells a story, truly English and conservative, of the climax of the efforts of the Leeds Smoke Abatement Society.[2] That Society had concluded, along with most other students of the subject, that municipal smoke inspection is a failure, and that the subject should be placed under the Alkali Acts and worked by central Government Inspectors.

This conclusion was not unnatural. The Society observed 79 boiler chimneys for an hour each, 51 of them emitted black opaque smoke for over ten minutes in the hour. But

[1] Smoke Conference Report, 1905, p. 107.
[2] Ibid. p. 15.

on the average Leeds only produced half-a-dozen convictions in the year, costing the culprits a fine of 10s. each. One year there was only one of these convictions as the nett result of local anti-smoke opinion. So the Society prepared a memorial in alliance with the enemies of smoke in Manchester and Sheffield, and obtained signatures from "all the principal sanitary, medical, architectural, and botanical Societies" in the north. It had the support of Trades' Councils and other Societies, and with its host of influential signatures, it and its deputation were simply refused reception by the President of the Local Government Board of 1896.

By their new Act of 1905 Leeds can now fine progressively £5, £10, £20; this last remaining the penalty for all subsequent convictions. Manchester may impose a daily penalty not exceeding £10 for not observing an order of abatement or prohibition. London may impose £5, £10, and so on, doubling each time for offences against the Act.

With regard to domestic smoke legal compulsion would have to begin in the tentative way which the conservatism of our nature demands—as in fact the manufacturers have been treated hitherto.

In new large houses gas or other smokeless cookers should be compulsory, and some smokeless method of making water hot, such as a coke boiler or a geyser. These could, however, only be compulsory in houses of a certain size; they would be too elaborate for a cottage, and I see no drastic method of treating the cottage kitchen or the sitting-room of the British citizen. Nevertheless, he need not make much black smoke; when he does, he should be fined as causing a public loss and nuisance, just as if he threw his garbage into the street. Moreover, a tax should be put on all fire-grates not admitted to be smokeless, thereby offering a fortune to a firm who could put a smokeless one on the market.

All this is not grandmotherly; it is not different from what we do every day. We regulate the purity of gas and the hours of work, and we specially watch dangerous industries; we dictate building materials and the size of chimneys, and the width of streets, and the height of buildings, but our sanitary regulations do not sufficiently extend to the air and the sunlight.

Mr. A. E. Fletcher, in one of his Reports as Chief Inspector of Alkali Works, says wisely:—

"There are difficulties in making any

change. Masters will not take the trouble to alter their furnaces, nor will the men alter their method of stoking their fires unless they are compelled. The numerous alterations made in the construction and conduct of chemical works during the last twenty years would never have been carried out but for the pressure brought on the manufacturers by means of the Alkali Act."

Average smoke in Nottingham was found to last 33 minutes in 10 hours. At that happy place the need for clean lace compels the manufacturers to prevent smoke. But shall not the nation have clean lungs as well as clean lace collars? Are the fineries of the rich and their dainty decorations to be so influential, but the bronchitis of the slums unavailing? That which compels the use of sufficient boiler power and careful stoking in Nottingham is surely a trifle of trifles compared to the gloom and slow degradation of physical life which goes on all over our ill-regulated country. Verily—

> "This is the day of the chattel,
> Web to weave and corn to grind,
> Things are in the saddle,
> And ride mankind."

The medical officer at Nottingham asserts that by careful stoking black smoke can be

prevented. He tells me that he m
careful stoking that the fire should be
back when stoked, and the new coal p
only in the front, thus making the fu..ace
work like a coking stoker run by hand. The town appoints two or three of the police for the special duty of watching chimneys, in which also the sanitary inspectors join. It is not usual to warn offenders before summoning them. One would suppose that the necessity for keeping the lace clean in Nottingham would find a parallel in many districts where fine textile fabrics are made.

To sum up, I propose the following changes:—

1. Omit the words "black" and "as far as practicable" and the statutory notice from the Public Health Act.
2. Make the fines cumulative and high.
3. Give power to the Court to order smoke-prevention appliances on the Chief Inspector's advice.
4. Put the inspectors under the Alkali Acts, and make them independent of local control.
5. Let each large district be under a competent chemist or engineer with scientific training.

6. Inspect domestic fire-grates, and make householders liable to a fine for excessive or protracted smoke. Remit a little from the rates of gas users by selling gas a trifle below cost. Compel the use of gas or electric cookers and coke furnaces where possible.

Besides a central body of inspectors, there ought to be a Ministry of Public Health, which would deal with smoke among many other important public questions which are now scattered over several Government departments. This proposal has been very forcibly made many times by Mr. Fred Scott, the Secretary of the Manchester Sanitary Association, who explains that there is at present no force capable of coercing a negligent Corporation; the President of the Local Government Board has neither the status nor the effective power to control. A Royal Commission did once recommend the appointment of such a Minister, who ought to be of Cabinet rank, but Lord Goschen's Bill, which attempted to carry it out, fell through because it was overweighted with changes in the incidence of taxation. Public health is doubtless a question as important and as complicated as those controlled by the Secretaries of State. Most of

us could record instances in which private interests have interfered with the performance of the duty of local bodies, who, therefore, need effective central coercive pressure.

CHAPTER X

NATIONAL COAL SUPPLY

It is not only on account of its smoke that the era of economy in the use of coal should be compulsorily ushered in without delay. The Royal Commission on this subject issued its final Report last year. This is its finding on the probable duration of our coal resources:—

"This question turns chiefly upon the maintenance or the variation of the annual output. The calculations of the last Coal Commission as to the future exports, and of Mr. Jevons as to the future annual consumption, make us hesitate to prophesy how long our coal resources are likely to last. The present annual output is in round numbers 230,000,000 tons,[1] and the calculated available resources in the proved coalfields are in round numbers 100,000,000,000 tons,[2]

[1] Including exports.

[2] It is difficult to remember statistics, but a hundred thousand million tons is an easy figure to retain, though not to realise.

exclusive of the 40,000,000,000 tons in the unproved coalfields, which we have thought best to regard only as probable or speculative. For the last thirty years the average increase in the output has been 2½ per cent. per annum, and that of the exports (including bunkers) 4½ per cent. per annum. It is the general opinion of the District Commissioners that, owing to physical considerations, it is highly improbable that the present rate of increase of the output of coal can long continue —indeed, they think that some districts have already attained their maximum output, but that, on the other hand, the developments in the newer coalfields will possibly increase the total output for some years.

"In view of this opinion, and of the exhaustion of the shallower collieries, we look forward to a time, not far distant, when the rate of increase of output will be slower, to be followed by a period of stationary output and then a gradual decline."

The Commissioners add:—

"Vast as are our available resources, it must be borne in mind that a large percentage of them are of inferior quality, or are contained in deeper and thinner

seams, which cannot be worked at the present cost." [1]

Mr. Price Williams, in elaborate evidence before the Royal Commission,[2] calculates that in a century from 1901 the population of Great Britain, now 37,000,000, will be 85,000,000; in two centuries, 135,000,000; in three centuries, 175,000,000; in four centuries, 201,000,000.[3] At that time the population will be just about as dense as that of Lancashire is to-day; it will give 3.47 persons per acre, against Lancashire's 3.65. The assumption in these figures is that the circumstances of the nineteenth century will, broadly, continue; that the decrement in the rate of increase since 1870 will still hold, and that there will be no artificial restriction of births in excess of what there has been since 1870. This factor is so uncertain that it will be safer to work without it and be on the safe side in estimating the amount of coal we shall require. It is clear that great economies must take place. These economies have for many years been growing, and we are rapidly increasing them.

Again, assuming that the decrement observable in the rate of increase in coal consumption

[1] Vol. iii. p. 20. [2] Vol. iii. p. 351.
[3] Vol. iii., Appendix V., Table 5.

during the last thirty years continues, *the coal in the proved coalfields would be exhausted in 209 years from the present time,* and *if* the unproved coalfields answer the Commission's expectations, they will give another eighty years' supply. These estimates are as near as we shall reach from purely physical considerations, and omitting all the effects of a higher price.

It will enable us to realise the extent to which we are increasing the consumption of our great national asset, if I mention that we use now in a single week in winter as much coal—5,000,000 tons—as was used in the whole of the year 1781, when Watt invented the steam engine.[1] It is also estimated that, by losses avoidable and unavoidable, we send to waste, on the whole, the heat of nineteen hundredweight of every ton of coal we burn in turning it into other forms of energy.[2]

Our consumption of coal has doubled in the thirty years from 1870 to 1900, including the coal exported and that used in foreign-going ships. Another calculation has been made by Mr. Martin on the assumption that the increase in output maintains its present rate, instead

[1] A. J. Martin, Brit. Assoc. Paper, 1906, p. 6.
[2] Ibid.

of falling as Mr. Price Williams expects. If this be assumed as basis *the whole of our "proved" coalfields will be exhausted in* 108 *years.* "Unproved coalfields" may possibly prolong the period to 122 years, and coal below 4000 feet deep, not now considered workable, might keep us going another eighteen months. Not that this absolute exhaustion is likely to take place. Every calculation which omits price is not intended to be actually realised. Long before we approach the end coal owners will raise the price and check consumption. Like Lord Penrhyn they can afford to wait. The coal will yearly increase in value. It does not seem improbable that ere another generation has passed away the price of coal may be raised to an equality with that of competing coal from abroad, whose freight is not likely to be less than 5s. a ton. If this happens our manufacturers will be on the footing of those in a country dependent on costly foreign coal, whose price is at the mercy of foreign tariffs. German and Belgian coalfields will still be worked, and will be our nearest source of supply. By that time no country may be willing to part with coal at all. Our factories cannot so survive. Manufacturers will go to the coal much more frequently than the coal

to the manufacturers. When our coal has gone the manufacturing and mercantile part of the greatness of England and all that depends upon it will have gone too. London will live by running hotels in which Americans can spend their holidays, and as a centre of culture and fashion; in Lancashire and Yorkshire sheep will wander over the ruined heaps of former towns; Manchester and Leeds will be visited chiefly for their Art Galleries and Libraries, their impoverished Universities and interesting old Town Halls, doubtless cleaned at last. The people—or those who survive—will have emigrated, and be working in cotton mills in Saskatchewan and Rhodesia.

Any one who remembers the upward jerks in the price of coal within recent years, when some quite slight check upon output or fillip to demand was enough to raise the price disproportionately, will not think the above a foolish terror; coal for warmth and for light must be had, and when necessity is upon the consumers, the price may prove enormously elastic. We had booms in the price of coal in 1872, 1890, 1900, and 1906. They are thus coming more frequently; and between 1900 and 1906 coal never dropped to its old normal price, and it is still rising. These booms are

believed by experts to be caused by fluctuation in the foreign demand. In a coal famine —which, of course, will occur in winter— what are our poor to do? Our navy, too, is absolutely dependent upon coal. This is a new question, for if the consumption of 1870 had been maintained and were to be continued unchanged in the future, our coal would have lasted nearly a thousand years. It is the increasing rate of consumption which, if continued, is so alarming.

It takes some time for a Royal Commission Report, particularly one referring to a danger prophesied for a time after our own, to saturate the public mind. But we hope it will do so in time; otherwise there is danger that this proudly enlightened generation of ours may go down to posterity as the Age of Waste; we shall be remembered as the people who spent 6s. per week per family on liquor and wasted coal by the pit mouth, in making coke, in open fires, and in steam engines of low efficiency, and dirtied ourselves and ruined our health in doing it.

The Royal Commissioners state that no substitute for coal as yet exists or is within sight. It would certainly be idle at present to think of living on radium, or transforming the energy of sunlight. "We are convinced

that coal is our only reliable source of power and that there is no real substitute. There are, however,[1] some possible sources of power which may slightly relieve the demand for coal." But England possesses neither water power, nor forests, nor tropical sun.

There is another conceivable famine threatening our descendants—a famine of bread. Sir William Crookes devoted his Presidential address before the British Association to this subject in 1898. He pointed out that the population of the world was overtaking its wheat fields; and he exhorted us to find in the laboratory some means of making—from the atmosphere or otherwise—a nitrogenous manure which would replenish our fields. We are living at present on nitrate of soda from the South American coast. This is likely to last less than fifty years. Now our coal contains the means of making sulphate of ammonia, the very manure we want. It is a bye-product of the manufacture of gas. When we burn raw coal all this is wasted. Bread goes up the chimney with smoke.

Mr. Beilby laid before the Royal Commission a careful classification of our coal consumption. The Commissioners accept

[1] Vol. iii. p. 17, Final Report.

the following figures in their report (vol. iii. p. 11):—

"Very few statistics are obtainable as to the consumption of coal in the various industries of the country, but we have collected information from many sources, and we think that the following estimate for 1903 may be regarded as approximately correct:—

COAL CONSUMPTION.

	Tons.
Railways (all purposes)	13,000,000
Coasting Steamers (bunkers)	2,000,000
Factories	53,000,000
Mines	18,000,000
Iron and Steel Industries	28,000,000
Other Metals and Minerals	1,000,000
Brick Works, Potteries, Glass Works, Chemical Works	5,000,000
Gas Works	15,000,000
Domestic	32,000,000
Total	167,000,000

In considering these figures from the point of view of possible economies, we would draw attention to Mr. Beilby's interesting calculation that out of an annual consumption of from 143,000,000 to 168,000,000 tons of coal in this country there is a possible saving of from 40,000,000 to 60,000,000 tons. Other

witnesses have confirmed Mr. Beilby on special points."[1]

Among the savings would be those by gas generators, gas engines, coke recovery ovens, gas cooking, heating by gas, electric traction, and smokeless chimneys. We should thus save one-third of the whole, and a sum of, say, £36,000,000 sterling; "about equal to the cost of the army," remarks Mr. A. J. Martin.

I therefore submit that the law should step in effectually to stop practices which smite our people with disease, choke them in ugliness, and waste the national asset on which we have built up our wealth and our national greatness. Modern England is the creation not so much of brains and liberty and free trade, as of our treasuries of coal.

The coal industry is peculiar in this that the more it flourishes the more the country is immediately benefited, but permanently impoverished; and the more coal is raised now the higher the price that can at an early date be charged for what is left. It is the familiar phenomenon of the apparent

[1] The "General Report," being Part I. of the Final Report, summarises the possible economies, and may be had for 4d. from Wyman & Sons, Fetter Lane, E.C.

prosperity of a man who lives on his capital.

Extremely cheap fuel, such as we have now in low grade coal, is actually a chief cause of the smoke nuisance, for it pays sometimes to be extravagant with cheap fuel rather than to economise it. An Italian manufacturer, who imports his coal from Wales, told me how necessary it was to economise so costly an article. He therefore uses mechanical stokers of the underfed type, with complete success. The time may, therefore, come in England when, by hard necessity, we may be driven to economise the coal which considerations of public well-being are not strong enough to prevent our waste of now.

Collieries, where cheap coal is at hand, and a good deal of it of poor quality, difficult to sell, are the most wasteful users of coal, and make the smokiest places. They are often in villages which are the creation of the mine, and owned by the colliery owner. Nobody lives there but workpeople, and nobody cares to interfere. The law should compel these villages to be as bright and clean as a soap village or a cocoa village. They might be, though it may cause some thought and some

immediate expense to the colliery owner, not generally a poor man.

One of our most strikingly wasteful processes, already briefly noticed, is that of making coke in beehive ovens, and not recovering the gas sent into the air. In 1899 it was estimated that recovery ovens made only one-tenth of our coke. By 1902 this had increased to half as much again. If the old-fashioned ovens vanished altogether we should save the equivalent of 3,000,000 tons of coal per annum.[1] Prejudices concerning the colour of the coke from the recovery ovens are, I am told, giving way.

This is, however, not a treatise on the many possibilities of fuel economy; it is merely concerned with the losses due to smoky combustion, and the serious danger to the nation in the waste of the great national asset on which we live. Everything points to the fact that some time during the present century we shall only be saved from a rapidly approaching exhaustion of coal by race suicide, or by such a condition of high price as we should now call a severe coal famine.

[1] Royal Commission, vol. ii. p. 33.

CHAPTER XI

FINAL

THIS book has been written in a restrained style, and depends for its effect on the eloquence of its facts. I close with a few words to the makers of smoke.

Although an economical method of combustion is likely to pay in the long run, a reform doubtless means a fresh investment of capital on apparatus, or on providing new boiler room, or installing gas or electric plant. This will not be done without compulsion in all cases. But there can be no genuine ground of complaint by a firm who overwork their boilers and thereby make smoke. Restriction will only put them on the level of their competitors who work their boilers normally. There will be no added burden on the trade as a whole in such a case.

In any case the public welfare is here so important and in such need of safeguard

that I think the public is justified in insisting that for ease in their businesses—businesses, it happens, in which most of our very wealthy men have been, or are, engaged, and have become wealthy thereby—men shall not be allowed to spoil the lives of Englishmen in general. Reforms of this kind always produce some hardship and much outcry, but time justifies them. They are in the regular line of progress. I believe that this is really the most curable of all our great national evils. It is not much complicated with other evils; it is not a deep-seated organic disease of the body politic, like poverty or unemployment, or low wages; not deeply ingrained in vicious natures like drink or gambling; not a traditional barbarism like war; it is just a piece of criminal negligence that could be cured in twelve months to our economic advantage, if the public conscience were awake and the magistrates ready to support public opinion. The engineers have done their part; there is a mechanical device to suit every one; but England goes on choking in gloomy fogs and breathing soot. It is altogether an error to say that "Dirt is cheap." Dirt is dear.

It will be a task for the future social

historian to explain why the English of our time were content to live in dirty and gloomy air. He will probably explain that it was a survival of the worship of that careless god *Laissez Faire*, under whose easy rule much wealth had been collected; that they who had made the wealth were the chief sinners, and though they were not bad or cruel the exercise of thought was a great effort to them, and their thoughts were already crowded with other affairs. They passively resisted the law, and the English people have always been patient, and also very busy; they even deceived themselves into the belief that a smoky chimney was a sign of active prosperity, and that "where there's reek there's brass."

We have inherited smoke from that noble but chaotic period when philanthropy was individualistic—when the franchise and free trade and the abolition of tests and taxes occupied Bright and Gladstone and Cobden. But it is time we gave heed rather to Kingsley and Ruskin, Morris and Carlyle, with their greater sense of the community, and their claim upon the State to regulate individualism. The pile of the feudal castle has given way to the greater pile of the modern factory. Every class in

every age in whose control lie the means of production and consequent power over others, needs watching for the public weal. No class has ever been fit to be entrusted with unfettered power; and the modern manufacturing firm or capitalist, wise and good as he often is individually, is no exception to that rule. In what I have said I have been obliged to treat a most excellent class of the community as though they were public enemies, whereas we know that they are neither better nor worse than the rest of us; that they are men who are bearing great responsibilities, and often honestly wishful to benefit their workpeople. Therefore I wish to guard myself against any undue personal severity in what I have said with regard to this serious public evil. It is always the case that the few who are wealthy and powerful tend to form a system of conduct which, without any personal ill-will or voluntary tyranny, presses hardly upon the poor. We admire the feudal castles of the days gone by, but they, alas, were the centres of tyranny and terror to the serfs who tilled the ground around them. These huge factories surrounded by working people's houses are politically different from that feudalism,

but it is still as necessary to maintain and defend the common rights of the public to health and happiness as ever it was in the days of the feudal masters of England. Those old barons too had the duties of their chivalry. They wielded power for the rescue of the weak. To-day knightly service must be rendered under the quieter name of public duty. Those in danger of oppression are not the aristocratic damsels nor the dispossessed heirs, but the workmen and work-girls of the nation. Their health, joy, and beauty, our modern knighthood must surely guard from the sulphurous smoke of their own mills. We would fain persuade the better-minded mill owners that to make smoke is disgraceful, inconsistent with self-respect and good will, and we want a public opinion determined to coerce the careless and selfish ones with an effective law.

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